SCIENCE TEACHER'S WORLD

Teacher's edition of Science World • September 9, 1959

Using *Science World* in Your Teaching

You will note that each major article in *Science World* is briefly reviewed in *Science Teacher's World*. The topics to which an article is related are indicated, and suggestions are made on how the article might be used in the classroom. Here are some ways in which you may take advantage of these features, thus making maximum use of the contents of each issue in your teaching:

1. Look over the brief reviews of each article in *Science Teacher's World*. File a three-by-five card for each topic that belongs in your course of study. You may want to make notes on the card, indicating some special use—"student report," "student project," "homework assignment," "motivation." File the cards under "units" and "topics" in your course of study. Refer to them when you plan your lessons.

2. Ask your students to save each issue of *Science World* and to keep their issues on file for future use.

3. Before you distribute copies of *Science World* to your students, look over the issue yourself. Determine the specific articles or features pertaining to your subject that you want to call to the attention of students.

4. The day after the magazine has been distributed, set aside about five minutes to enable students to tell *each other* what articles they found especially interesting and pertinent to the course. This might also be the day for your class to discuss the "Curiosity Catchers" problems.

5. *Organize* the participation of your class in the "Curiosity Catchers" problem (*see page 29*). If you can devise a particularly clever and effective way of doing this, we should be interested in hearing about it.

The staff of *Science World* is dedicated to helping the science teacher enrich his teaching of science. Your suggestions on how we can be increasingly helpful will be very much appreciated. May we hear from you?

Science World Now a Scholastic Magazine

With this issue *Science World* becomes a member of the Scholastic family of publications. The bi-weekly classroom science magazine, formerly published by Street & Smith, was acquired by Scholastic Magazines this summer.

Science World will be oriented to the requirements of the science curriculum for grades 7-12. It will feature articles, science news, biography, and classroom and individual projects in the fields of general science, biology, chemistry, physics, and earth science.

A bonus feature of the new *Science World* will be a four-page section in each issue: "Tomorrow's Scientists." Formerly published by the National Science Teachers Association, "Tomorrow's Scientists" now becomes part of the regular contents of *Science World*.

The National Science Teachers Association will cooperate officially with Scholastic Magazines in the production of *Science World*, and will continue to supply projects for publication in the "Tomorrow's Scientists" section of *Science World*. These projects will consist of winning entries in the program of Student Achievement Awards, sponsored by the NSTA.

To all subscribers—new and old—we promise a vigorous publication, geared to the science curriculum, and alert to the needs and abilities of the students to whom *Science World* is addressed.

Lightning Doesn't Strike (pp. 6-8)

Physics Topics: Static electricity, conductors and insulators, lightning arresters, and circuit breakers.

Chemistry Topics: Ionization, nitrogen fixation.

Biology Topics: Air purification, sources of nitrogen compounds.

General Science Topics: Weather, electricity, safety, first aid.

About This Article

Every form of lightning—from fork lightning and heat lightning to St. Elmo's fire—is not only beautifully described but scientifically interpreted. Many common superstitions or erroneous notions about lightning and thunder are dispelled. Lightning, the reader learns, is essential to the scheme of life.

Man must learn to live with lightning. To live with it, he must understand it. Understanding has led to the development of lightning rods on buildings, lightning arresters and circuit breakers at electric power-plants and at points along transmission lines. It has led to the use of static discharge strips on the wings of airliners. But each one of us may at times find himself in a position where *he* must know how to live with lightning. Knowing what to do and what *not* to do, so clearly emphasized in this article, may spare the reader from becoming one of the 2,600 Americans who every year are killed or injured by lightning.

Teaching Suggestions

This lucid and dramatic essay on lightning may well serve as a motivation and introduction to the study of

static electricity; or you may want to use it as a *culmination* of the study of this topic. In either case, you may want to demonstrate to the class—on a minute scale, to be sure—some of the phenomena involved in lightning. For example:

1. Hold a sheet of newspaper against the blackboard or wall. Charge the paper by rubbing it vigorously with the palm of your hand. The paper will stick to the blackboard until it is discharged.

2. Charge two inflated rubber balloons by rubbing them against woolen clothing. Show that they repel each other, but that they will adhere to the wall of the room.

3. Rub a hard-rubber comb or fountain pen against wool. Then hold it near a thin stream of water from a faucet.

4. Charge a Leyden jar and draw a spark from it.

5. Operate an induction coil to obtain continuous sparking. Call attention to the sound. Demonstrate the heat by holding a piece of paper in the path of the spark.

Should you wish to assign this article as homework-reading, the following questions should focus attention on significant points:

1. "Lightning doesn't strike, it leaps!" Where does it leap *from*?

2. Explain this statement: "Lightning is essential to the scheme of life."

3. Explain why lightning storms are more likely to occur on a hot day than on a cool day.

4. Air is not normally a conductor of electricity. Explain how lightning, which is electricity, comes to pass through air.

5. Explain this statement: "Lightning may be of different thickness or duration."

6. A common belief is that thunder is "air coming together." What is the *true* explanation?

7. How can the distance of a lightning flash, in miles, be calculated by timing its thunder?

8. Describe each of the following kinds of lightning: forked lightning, heat lightning, sheet lightning, St. Elmo's fire.

9. What should you do when you find yourself, during a lightning storm, (a) in an open field, (b) at home, (c) at the beach, (d) on a golf course.

10. Why is seeking shelter under a tree during a lightning storm especially dangerous?

Our Tiniest Chemical Laboratory (pp. 9-11)

Biology Topics: The living cell, mitosis, heredity, evolution.

About This Article

Beginning with Robert Hooke's observation of "cells" in 1665, and leading all the way to Dr. Beadle's Nobel Prize-winning experiments in modern times, Dr. Asimov ties together the work of Mendel, Morgan, and Beadle into a neat and connected story. Basically, the article deals with genes—how they replicate themselves, how they distribute themselves in dividing cells, and how, through their production of enzymes, they direct the many and complex chemical reactions that constitute life. The reader is introduced to a recently developed and very active branch of biology—chemical genetics.

Teaching Suggestions

The biology student will be in the best position to profit from this article after he has studied cells, cell reproduction (including mitosis), plant and animal reproduction, and heredity. The article might then serve as a sweeping and unifying review of previous studies, to bring the student to some of the exciting research now being conducted by chemical geneticists.

The article can also serve as a springboard for class discussion of careers in biology, as well as the exciting new areas of biology such as chemical genetics, radiology, and space medicine.

Polio Fighter (p. 20)

Biology Topics: Virus diseases, tissue culture.

General Science Topics: Disease control, heroes of science.

About This Article

Jonas Salk—the boy, the man, the scientist—is the central figure in the story of the development of anti-polio vaccine. What makes the story particularly valuable in the science class are the interwoven nuances giving insight into scientific research.

The work of Dr. Salk, too, is described as a step by step development—finding the best tissue culture on which to grow the virus; developing the best medium for growing the tissue; finding the best way to kill the virus before it could be used as a vaccine; then conducting preliminary tests on monkeys and on recovered polio victims—all before "the tremendous field test" that catapulted Dr. Salk to fame.

Teaching Suggestions

At the beginning of the term, when the biology course is being introduced, this article may be read in class (1) to illustrate the scientific method in action, (2) to show the human side of a typical scientist, (3) to show how each scientist's work depends on the work of

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SCIENCE WORLD
TEMBER 9, 1959 • VOLUME 6 • NUMBER 1 • A SCHOLASTIC MAGAZINE

Lightning Doesn't Strike!

SEE PAGE 6

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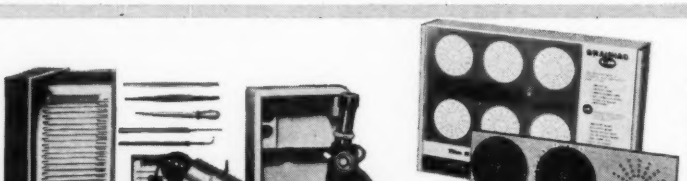

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Your Place in Science

Welcome to the new *Science World*. This magazine shares your interest in today's science, and in the exciting adventures of the men and women who are creating today's achievements.

Science World also shares your enthusiasm for the science of tomorrow. Science never stands still. The amazing discoveries of today were made possible by the research and exploration of the pioneers of yesterday. Tomorrow's science frontiers will be conquered by you.

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—The Editors

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GRADUATE SPECIALIST

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Infinite Space

Dear Editor:

While reading your article on "Giant Meteorites" in the April 7, 1959, issue of *Science World*, I became more interested in space. As a result, I have been wondering whether or not space is infinite. If it is not, how does it end?

D. J. Alan McIlroy
Glenleslie
142 Manse Road, Motherwell,
Lamarkshire, Scotland, Great Britain

Have you ever thought about this question? If so, write us and tell us what you think is the answer to Alan's question. We will print the best replies in a forthcoming issue of *Science World*.

The Electric Eel

Dear Editor:

How does an electric eel generate electric current?

Bruce Nolin
Riverside Drive
Chestertown, New York

Answer: Actually, scientists still are not certain of how an electric eel generates its current. Many scientists do, however, agree on the following explanation:

One fifth of the electric eel's body contains most of its vital organs. The portion which remains contains the organs which produce the electric current. There are three pairs of these organs running almost to the tip of the tail and two smaller pairs under these. The tissues of these organs resemble the plates in a storage battery. They are built of sections arranged one behind the other.

The head of the electric eel is positive; the tail is negative. The current flows from head to tail. The electric eel depends on its electric shock not only to catch food but also to protect itself from enemies.

Scientists believe that the smaller organs send out weak shocks which act as signals to other electric eels. These weak shocks come before stronger ones, and may serve to warn enemies.

The electric eel's voltage may reach 200 to 300 volts, enough to stun a man or horse. For the maximum shock to take effect, the head and tail of the eel must touch different points on its victim's body.

Emotions and the Brain

Dear Editor:

I would like to know if certain areas of the brain are occupied by certain feelings.

James Phillips
1145 Westview Avenue
Ashland, Ohio

Answer: There are certain areas of the cerebrum which specialize in specific functions. Animal experiments and studies of accidental injuries to human brains have revealed to scientists that the areas for thought, memory, and feeling are located at the front part of the cerebrum. The area for sight is located at the back, and the area for hearing at the side of the cerebrum. The map below shows which part of the cerebrum controls each function.

Science for Better Living (Harcourt)

Findings reported last month by Dr. Jose M. R. Delgado, a brain specialist and associate professor at Yale School of Medicine, New Haven, Conn., show that bossiness, eating habits, and affection can be changed by electrical stimulation of the brain. A weak, painless electrical charge may produce changes that are in many cases drastic.

Hair-thin electrodes are surgically planted in various parts of the brain. Stimulation usually lasts as long as the current is on. In some areas, however, the effect continues for three days.

An electrical charge to one area of a monkey's brain wiped out the domineering characteristic of "bossism" in some monkeys. When the current was stopped the animal went back to his normal "bossy" self.

Stimulation of another area of the brain caused the monkey to increase the amount of food he ate by as much as 700 per cent. When this area is destroyed the animal loses his appetite and may starve.

Stimulating an area in the back of the brain of a rhesus monkey results in a fighting response. Stimulating another area of the brain made the animals very affectionate.

Dr. Delgado's research is not confined to monkeys. He has made tests on mental patients and epileptics. Electrical stimulation has brought about such reactions as laughter, fear, and affection.

Dr. Delgado reported that his studies "support the distasteful conclusion that emotion and behavior can be directed by electrical forces and that animals and humans can be controlled like robots by pushbuttons. This assumption . . . must be qualified," he went on.

Electricity "cannot create physical and mental patterns. It can only disturb, stop, or activate them. Brain stimulation can bring forth an emotional state, but it cannot change the basic characteristic of the experimental subject."

How Narcotics Work

Dear Editor:

I am interested in knowing what causes narcotics to affect the human body.

Charles West
1780 Conejo Drive
San Bernardino, Calif.

Answer: Narcotics are depressants which slow down the work of your body cells. They affect the nervous system in such a way that after a person uses them for some time, he actually feels physical and mental distress without them. He becomes *addicted* to the drugs. Addiction is much more than a habit. It is a compulsion. An addict cannot help himself. He needs others to help break him of his dependence on drugs. Some addicting drugs are opium, morphine, heroin, and marijuana.

Are there any questions that puzzle you? Send them to *Science World*. We'll try to answer the most interesting—and occasionally request the answer from *you*!

By BRUCE BARGER

Lightning DOESN'T STRIKE

Scientists have exploded myths about lightning . . . usually it doesn't travel from the sky to the earth

LIGHTNING is a giant surge of electricity between sky and earth. Usually it doesn't strike. It leaps.

Four times out of five, a powerful electrical discharge jumps from the earth, rips up through the air, and meets head on an equally powerful force coming down from the sky. The fifth time the direction is reversed. It happens so quickly, with such a blinding flash, that many people think they see lightning strike the ground.

Every day about 44,000 thunderstorms lash the earth. Each day nearly 9,000,000 lightning bolts tear through the air, at the rate of 6,000 a minute, 100 every second.

Every year lightning kills nearly 600 Americans, injures 2,000 more, ignites 6,000 forest fires, destroys hundreds of head of cattle, and wreaks other property losses that exceed $100,000,000.

Yet lightning fits into the supreme orderliness of nature. In fact, it is a force that helps to keep nature in balance. It helps balance the electrical charges in the atmosphere with those of the earth.

Its electrical charges combine dust, smoke, and other solid particles in the air. These particles are then washed to the earth by rain. Without thunderstorms and lightning the air might soon become so polluted that all life would die.

Lightning is also the world's largest manufacturer of fertilizer. It produces 100,000,000 tons of nitrogen compounds every year. The air is about four-fifths nitrogen. During an electrical discharge, electrons are stripped away from some of the atoms in the air. These atoms combine into molecules such as nitrous oxide. Rains carry these nitrogen compounds into the soil. Without nitrogen green plants would wither and die.

Wide World photo

High count: 48 electrical surges in one bolt at New York's Empire State Bldg.

The Storm Builds Up

Lightning starts beneath one's feet and above one's head.

Earth and its atmosphere are part of an electrical field. Oppositely charged particles on the surface of the earth and in the atmosphere are never at rest. For the atmosphere is never at rest.

On a normal day the air temperature is colder by three degrees F. every thousand feet above the earth. On a warm day the air near the ground becomes heated and rises. The friction caused by this upward motion of warm air generates static electricity.

The warmer it becomes the more rapid is the rise of air. As the warm air rises it is cooled. Finally it no longer can hold the moisture it contains. This moisture then condenses into clouds. When the air is dry, high flying cumulus clouds are formed. When moisture-laden air constantly rises, fed into the sky in ever increasing quantity, raindrops begin gathering in the clouds.

Soon a thunderhead takes shape. Rushing air currents create an enormous turbulence. Moisture is hurled higher and higher aloft. A great churning motion begins, reaching as high as seven miles above the earth. Downdrafts at speeds of 160 miles

an hour are as violent and vicious as updrafts.

Within minutes the thundercloud becomes supercooled. Hail and ice particles form. These are flung about in furious agitation. Ice particles bouncing off hail acquire positive electrical charges and are carried to the top of the cloud. Falling hail, even as it melts, transports negative electrical charges to the bottom of the cloud.

As these negative charges become stronger and stronger on the underside of the cloud they attract an equal number of positive charges on the earth. These positive charges have been building up on the surface of the earth under the gathering storm cloud.

The positive charges then begin racing along the earth directly below the wind-hurtled cloud, following the cloud like a shadow. The charges zoom up trees, skim across fields, swish over lakes, dart through people, race along wires, hurtle down roads, zip up tall buildings.

Lightning Has "Feelers"

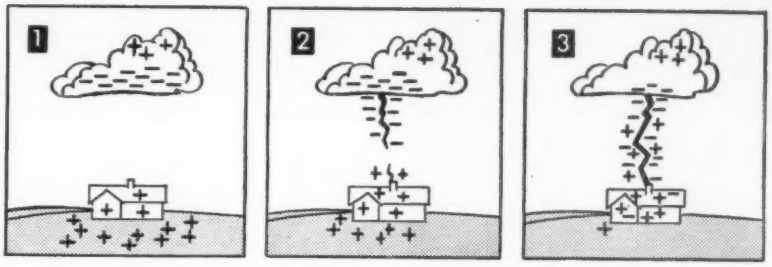
The positive and negative charges try to reach each other.

But air is a poor conductor of electricity. It contains too few atoms to bridge easily the areas of the opposite charges. But sooner or later little lances, invisible-to-the-eye pathways, are jabbed downward from the cloud. Little probing tongues of electrons begin to leap from high points of the earth's surface.

The electrical streamers from the bottom of the cloud dart downward 60 to 180 feet toward the earth, ionizing air particles, causing them to become conductors of electricity.

Before one streamer dies out another follows, then another and another. Each pushes out farther and farther, 60 to 180 feet at a time, trying to create a "path" for the negative charges. At the same time the positive charge on the earth has been increasing. Streamers leap up from high points on the earth's surface below the moving cloud.

Suddenly, within a thousandth of a second from the time the first streamer poked downward from the cloud, the path of ionized air nears the earth. Instantly charged particles on the ground leap up. The path is completed. Nature's biggest spark becomes a brilliant flash.



(1) Droplets of water in cloud become electrically charged by friction. Positive charges rise to top and negative charges go to bottom. At the same time, positive charges gather on the earth below the cloud. Air between acts as insulator. (2) Charges increase and air loses insulating quality. "Streamers" of negative electricity from cloud and "feelers" of positive electricity from earth form. (3) In a split second, a gigantic spark of lightning—millions of volts—jumps the gap. Thunder is sound wave from air that is suddenly heated and expanded by bolt.

To create this brilliant flash, powerful electric charges surge down from the cloud and up from the earth along this path. Behind the first surge comes a second, a third, often a fourth (48 is the maximum ever recorded). From start to finish the visible discharge lasts from 1/500th to 1.5 seconds. It is so incredibly fast that the series of surges appear as one blinding crescendo of light.

A bolt may be as thin as a hair, as thick as the calf of a hefty football player's leg. It may have traveled five miles between ground and cloud, although the average length is 5,000 feet.

The "Sound" of Thunder

Some bolts are "cold," others 27,000 degrees F., hotter than the surface of the sun. A cold stroke flashes by so fast—20,000 miles a second—that it sets no fire, yet it can explode a tree, a haystack, even a house. The hot strokes last longer, up to 1.5 seconds, containing millions of volts and discharging up to 345,000 amperes of current, enough to light all the bulbs in a good sized city.

After the flash comes thunder. Thunder is caused by the collision of billions of ionized atoms. These are hurled together at very fast speeds by the explosive expansion of air surrounding the intensely hot path of the bolt. The same thing occurs when a firecracker is shot off or dynamite detonated.

To determine how far away a lightning bolt occurred, count the number of seconds between sight of the flash and sound of thunder. Divide by five. The answer is in miles. But thunder cannot be heard more than 18 miles.

Streak, Fork, and Sheet

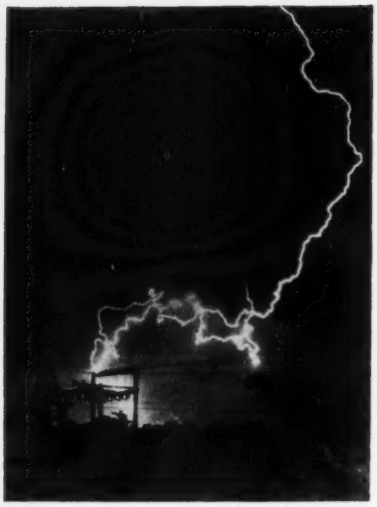
Some lightning thrusts are so slow they produce no thunder. The charge is drained off so gradually that an explosive clap is not created by the lightning.

Streak or forked lightning is the kind most commonly seen. The probing fingers of electrons appear to be nervously seeking a path of discharge. This accounts for the effect of red-hot jagged javelins being hurled through the heavens. Sheet lightning is the discharge over a wide area, usually from cloud to cloud in the upper and lower parts of the atmosphere. Some sheet lightning is ten miles long.

Heat lightning is ordinary lightning that is so far away we cannot hear thunder. Or it may be the reflection on clouds of flashes beyond the horizon.

Years ago sailors regarded with awe and superstition the eerie glow on the tips of spars and masts of sailing vessels. It was called St. Elmo's fire. St. Elmo's fire is nothing more than visible electrical charges built up on the earth leaking off into the air.

It is a warning that conditions are ripe for lightning, for the big leap of positive charges from the earth to



General Electric photo

Lightning leaps skyward from oil derrick and power lines in Oklahoma oil field.

meet negative streamers rushing down from the sky. Similar leakage occurs atop church spires, tall buildings, and lofty trees. It is at needle points such as these that lightning does most of its jumping skyward.

Man-Made Lightning

After spending many years studying the relationship between lightning and static electricity, Benjamin Franklin flew a kite in a thunderstorm. He proved that lightning is electricity. The sparks that flew off his key probably were discharges of stored-up electricity in the air. If he had lured a lightning bolt between the earth and sky he very likely would not have lived to tell of it.

Franklin's was a notable achievement. He invented the lightning rod, and helped open the door to man's taming of lightning.

Scientists study lightning most comfortably, however, in laboratories where they have equipment for making lightning. There they have developed many devices for taming lightning: lightning arrestors, special circuit breakers, and other safeguards on utility lines that lace the country. Light, power, and telephone service continue virtually uninterrupted during an electrical storm. No longer is there knockout damage to power stations or costly fires due to overheated power lines.

Although there are many events and circumstances which determine the precise time and place at which a lightning bolt will occur, today's scientists can suggest several very wise safety rules. For example, they know that a charged cloud will always discharge through the shortest air gap.

If you are in an open field and are the tallest object around, you become a ripe target. Lie flat on the earth or seek a gully and lie prone in it.

Keep away from overhead wires, wire fences, or any metal object during a thunderstorm.

If you cannot find a gully, make a beeline for the nearest house. Steel buildings, especially skyscrapers, are very safe because their framework carries off the charges harmlessly.

There is little danger of being killed or injured by lightning in a modern home. But play it safe; stay out of the bathroom and away from open windows, fireplaces, and the front porch—so you do not complete a circuit.

If antennae are properly grounded, use the TV set and radio as you normally would.

Do not swim during a storm. Lightning leaps upward from the water as it does from land, and often along water.

Don't take haven under a tree. Trees growing in the open, singly or in groups, are in more danger than those in a dense forest. Trees in sandy and loam soils are struck more often than those in clay soils.

Safety Do's and Don'ts

The danger of being near a tree does not come only from the electrical discharge. There is also the risk of being hit by flying pieces of debris. A lightning bolt going through a tree is said to heat the sap instantly far above the boiling point. The gases formed cause the tree to explode in all directions.

The safest place to be during a lightning storm is in your auto surrounded by a metal body on rubber tires.

Most deaths from lightning occur in the open.

Most fatalities occur during the afternoon between noon and 6 p.m. A substantial number are killed during the evening and night. Fewest deaths are recorded during morning hours.

Lightning current passes instantly through a person in its darting path. It paralyzes the nerves and muscles controlling the breathing mechanism. If a victim is not killed outright it is possible to revive him by artificial respiration. Victims are numb and unable to speak at first. When they regain consciousness they usually suffer muscular pain or stiffness for only a short duration.

Lightning, being electrical in nature, can easily produce some strange effects. For we are dependent on so many electrical devices and appliances. Once it set fire to a building, leaped across the street, touched off a fire alarm box, brought firemen hurriedly to the scene. They put out the fire.

Before dawn lightning struck upwards through a church steeple, short-circuited the chimes mechanism. The chimes began playing the hymn, "Be Still My Soul."

Ancient Mystery Exploded

No longer is lightning the mystery that ancients thought it to be. We know that it is neither the flaming spears the great god Zeus supposedly hurled at his females, nor the flames escaping from the stars.

Courageous studies by many scientists throughout the years have given us much insight into the true nature of lightning. But we are still surprised at its many forms and facets.

Photo of lightning stroke on lake surface was taken by amateur photographer.

General Electric photo

By ISAAC ASIMOV

Our Tiniest Chemical Laboratory

Scientists may find the answers to many riddles by working within the cell itself

THERE are twenty five trillion of you, approximately.

You're just one person, of course, but you're divided into tiny compartments, and there are at least twenty five trillion of them. Each little compartment is a busy chemical factory. Each takes in raw materials, processes them, extracts energy, manufactures replacement parts, stores reserve supplies for itself and for neighboring factories, and disposes of wastes.

All the compartments cooperate with each other. When cooperation ceases, you die.

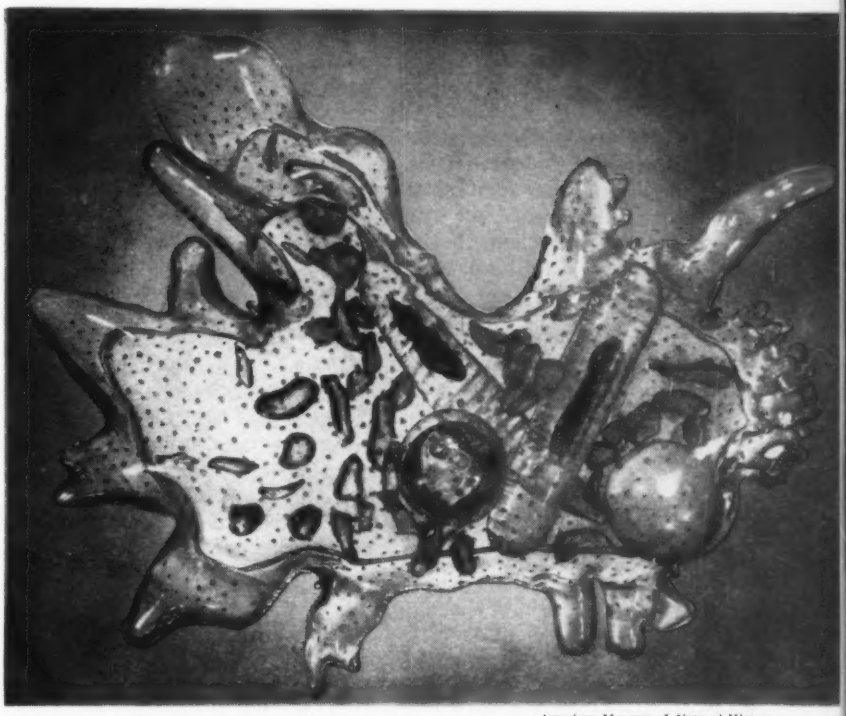
These compartments were first seen in 1665. That year the English scientist Robert Hooke studied a thin slice of cork under a microscope. He said that it was made up of tiny holes, separated by thin walls, something like a honeycomb. He called the little holes *cells*, from the Latin word *cella*, meaning "a small room."

The Unit of Life

During the next century and a half, scientists observed the structure of other tissues. All seemed to be made up of tiny units separated by walls or thin membranes.

Hooke's name was applied to all of them, although in living tissue the compartments were not empty (not really "cells" in the true meaning of the word). Living cells contained a jelly-like fluid that was eventually named *protoplasm*, from two Greek words meaning "first-formed."

In 1838 and 1839, two German biologists, Matthias Jakob Schleiden and Theodor Schwann, suggested that all living things, plants and animals alike, are made up of cells. The cell, they said, is the unit of life. This *cell theory* is one of the foundation stones of modern biology.



American Museum of Natural History

Three-dimensional model of an amoeba. One cell performs all the functions of life. Can you identify the various structures which make up this organism?

Most microscopic organisms are single cells. Protozoa, algae, yeast, and bacteria are all examples of *one-celled organisms*.

The physical characteristics of larger, *many-celled*, organisms depend on the activities of their individual cells. When you move, individual muscle cells are contracting. When you digest food, individual cells—in glands and intestinal linings—are manufacturing chemicals that break down the complicated food substances. When you see, hear, or feel, individual nerve cells are receiving sensations and reacting to them. When you grow, it is because individual cells grow and divide in two; grow and divide in two again, and so on.

In fact, all many-celled organisms start as a single cell. This cell is a *fertilized ovum*, formed from the union of two cells, one from one parent, one from the other. This single cell divides, divides again. After about fifty divisions, a fully formed creature results (fewer divisions for a small creature, a greater number for a very large one).

The starting cell of man and oyster and even dandelion are much alike, chemically. All cells of all organisms are made up of protein, fat, carbo-

hydrates, nucleic acids, and so on. All are remarkably similar among themselves. All cells require small quantities of the same vitamins, traces of the same minerals. Yet different fertilized *ova* develop differently.

Let's take a look at some of your twenty five trillion cells. Where will you get these cells? All you have to do is gently scrape the inside of your cheek with the flat end of a toothpick. Place a drop of diluted iodine solution on a microscope slide. Spread the material you collected into the drop. At first use the low power of a microscope to observe one of your own cells. Then switch to high power. Do you see your cells? What do they look like?

Even if you don't have a microscope, you can still observe cells. Peel off the brown outer "skin" of an onion. Look at the part of the skin that was against the onion—the inside. You will see the outline of cells!

Exploring Cell Differences

More and more, biologists are probing into the delicate differences that must exist from cell to cell.

One basic line of research began in the 1860's, when an Austrian monk, Gregor Mendel, experimented with pea plants. Carefully he crossed one variety of plant with another. He observed the way in which certain physical characteristics showed up in the new generation.

As a result of his experiments, he decided that every plant contained two factors for each physical characteristic. The plant ova and pollen grains produced by each plant, however, received only one of each pair of factors. When a pollen grain combined with an ovum, the factors were combined again in new pairs. This new combination might or might not be identical with the old one.

By using statistics, Mendel was able to predict just how various characteristics would be inherited. Thus he originated the science of *genetics*. Unfortunately, Mendel's published description of his work remained unnoticed by other scientists for thirty years.

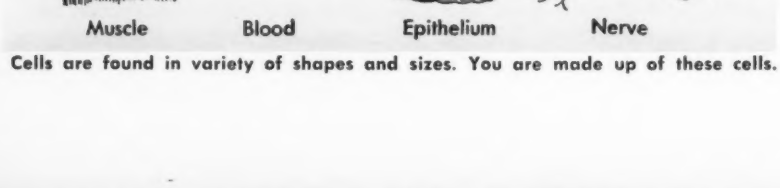
Yet Mendel never studied the plant cells themselves. What were these mysterious factors of his, which carried over physical characteristics from generation to generation?

Well, while Mendel's work remained in obscurity, other scientists were studying the cell. In the 1860's various dyes were made in the laboratory by chemists. Biologists washed solutions of these dyes over thin slices of tissue. They found that some dyes stained the cell, coloring certain parts of the cell, and leaving others uncolored.

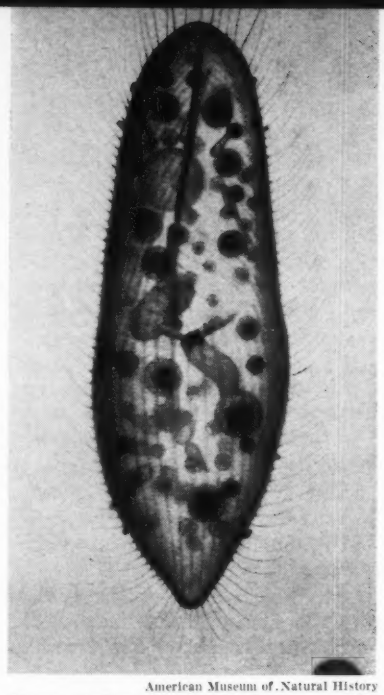
During the first half of the nineteenth century, the only part of the cell which could be made out clearly was the *nucleus*. This was a small central region marked off by a thin membrane. Using chemical *stains*, however, little specks could be made out both inside and outside the nucleus. In 1879 a German biologist, Walther Flemming, found a dye which stained certain areas inside the nucleus. He called these stained areas *chromatin*, from a Greek word meaning "color."

He found that interesting things happened to the chromatin when a cell divided. In the first stage of cell division, the chromatin material gathered into a little tangle of threads (later named *chromosomes*). These chromosomes divided into two equal groups. Half of them moved to one end of the cell, half to the other. Every time a cell divided, each new cell had its fair share of chromosomes.

Furthermore, in any given organism, all cells (with one important exception) had a fixed number of chromosomes. This number doubled just before division, so when the new cells formed, each had the appropriate number. Thus, if a cell ordinarily has ten chromosomes, the number becomes 20 just before division. After division, each new cell has half of 20, or ten, which is the proper number.



Cells are found in variety of shapes and sizes. You are made up of these cells.



American Museum of Natural History

Photo of three-dimensional glass model of paramecium. Can you label organs which make up this one-celled animal?

The important exception mentioned in the preceding paragraph are the sex cells—ovules and pollen in plants, ova and spermatozoa in animals. These contain only half the ordinary number of chromosomes. Thus, when sex cells combine to form a fertilized ovum, the proper number results.

Chemical Factory in Cell

When Mendel's descriptions of his work were discovered in 1900—thirty years after publication—scientists saw some interesting connections between chromosomes and Mendel's genetics. Chromosomes behaved like the genetic factors governing physical characteristics. But chromosomes existed in pairs. Each physical characteristic, then, could be considered as controlled by two factors (called genes), one on one chromosome and another on its pair. The sex cells had only one gene for each physical characteristic, for they had only one chromosome out of each pair. The pairs of genes were formed once again in the fertilized ovum. The new combination resulting depended on the laws of chance.

To these research scientists, the whole machinery of life seemed to depend on the chromosomes. Somehow chromosomes control the formation of certain protein molecules called *enzymes*. Each enzyme, in turn, controls some particular chemical reaction.

We know now that the exact way in which the chemical machinery of a cell works depends on the nature of the chemical reactions going on in the cell. The enzymes, in turn, are controlled by the exact structure of the genes in the chromosomes. It all goes back to the chromosomes.

Just before a cell divides, its chromosomes double in number, as we've learned. For this to happen, however, each chromosome must form another exactly like itself, if the chemical characteristics of the new cells are to stay the same as those of the parent cell.

Every once in a while, though, the new chromosome formed is not exactly like the old. In this way, a cell with a changed chemical machinery can arise. The result is called a *mutation* (from a Latin word meaning "change").

Solving the Jigsaw Puzzle

One type of mutation might derange the chemical machinery which regulates the growth and division of the cell. Such a mutated cell might begin to grow and divide without limit. In this way, a *cancer* may start in the body.

If the new deranged cell happens to be a sex cell, a fertilized ovum would result that could give rise to offspring that had a physical characteristic none of its ancestors had. This would be a mutated organism, or *mutant*.

In 1906 an American biologist, Thomas Hunt Morgan, started working with fruit-flies to study their mutations. Fruit-flies are quite small, breed quickly and in large numbers, and have simple characteristics that are easy to study. In 1927 another American biologist, Hermann Joseph Muller, found that he could increase the number of mutations by exposing the fruit-flies to X rays. The science of genetics made important advances. Both Morgan (in 1933) and Muller (in 1940) received Nobel Prizes for their work.

But why work with pea plants and fruit-flies only? The cell is the unit of life. Why not get as close to the single cell as possible? About 1941 an American biologist, George W. Beadle, began working with a pink bread mold, called *Neurospora crassa*. Instead of studying physical characteristics such as shape or size, he studied chemical characteristics. He tried to find out just how the mold inherited its enzymes.

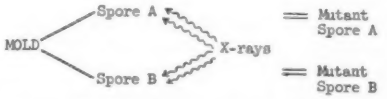
Ordinarily a spore of Neurospora will grow on a mixture of sugar, some minerals, and a vitamin called biotin. If Neurospora is exposed to ultraviolet light or X rays, however, some of the spores formed are mutant. They will not grow on the ordinary food mixture.

Beadle reasoned that these mutant spores lost a gene. This made it impossible for them to form some certain enzyme needed to manufacture some vitamin or some protein building block necessary to life and growth. Since he could not find the gene directly, Beadle tried to find the enzyme.

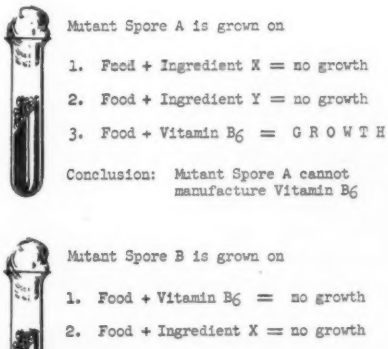
To find which enzyme was missing, Beadle added various ingredients to the food—vitamins, protein building blocks, or other important compounds, one by one. One of these would allow the spore to grow, so the missing enzyme must ordinarily allow the mold to form that compound.

Beadle then went further. When he found out what compound was needed, he added compounds that were very like the one needed by the mutant spore. The spore would grow on some of these similar compounds but not on others. In other words, it had the enzymes to change some compounds into the needed ones, but not the others.

By using a great many mutants, Beadle slowly put the results together like a jigsaw puzzle. One mutant might be missing a gene at this point, another at a second point. Eventually he worked out the complete, or nearly complete, route by which certain important chemicals were formed in cells. By crossing various mutant strains of Neurospora with normal strains and other mutant strains, he also studied how enzymes were inherited.



X rays change normal spores to mutants.


Mutant Spore A is grown on
1. Food + Ingredient X = no growth
2. Food + Ingredient Y = no growth
3. Food + Vitamin B6 = GROWTH
Conclusion: Mutant Spore A cannot manufacture Vitamin B6
Mutant Spore B is grown on
1. Food + Vitamin B6 = no growth
2. Food + Ingredient X = no growth
3. Food + Amino Acid = GROWTH
Conclusion: Mutant Spore B cannot manufacture Amino Acid

This is diagram of experiment Beadle used to find missing genes in mutants.

Cell Becomes a Laboratory

Since all cells are so similar, the results on Neurospora were useful for an understanding of the cells of higher organisms, even those of man. In 1958 Beadle received the Nobel Prize for his work.

This form of *chemical genetics* is now being used on bacteria also. Thus, single cells of the simplest type are being battered by X rays. From the broken machinery we may get notions of what the original is like. The tiny chemical factory of the cell has now, indeed, become the world's tiniest chemical laboratory.

Scientists are working in their laboratories now with every tool they can develop. They are asking themselves—

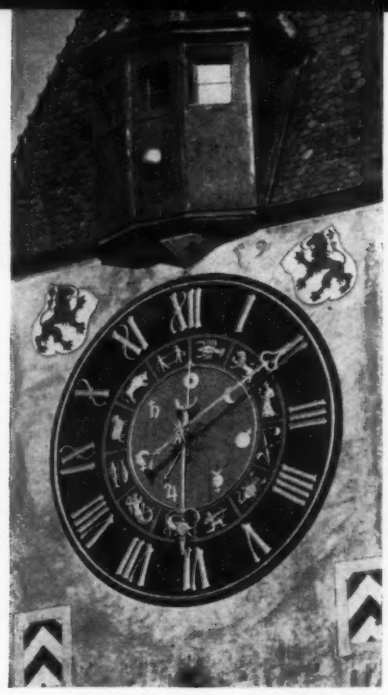
Just how does a gene produce another like itself? Why does it produce a changed gene every once in a while? Just how does a gene produce one particular enzyme and not another? Just how does an enzyme bring about one particular chemical reaction in the cell and not another? How do chemical reactions in the cell control the large physical characteristics of the whole organism?

By working within the minute laboratories of the cells, scientists hope to find answers to these questions. When those answers are found, many of the mysteries of life will be solved.

By ROBERT TOTH

How Long Is a MICROMICROSECOND?

Measurement is a fundamental tool of science . . . it is part of our basic equipment for understanding nature



Swiss Travel Bureau

Swiss clock made in 1559 shows hour, minute, day of week, season of year, and phase of moon. As tool of scientific measurement, this example of Swiss skill is more artistic than accurate.

Hughes Aircraft Company

Atomic clock won't vary one second in 1,000 years, "ticks" 24 billion times each second. Clock above will be mounted in satellite to orbit Earth in experiment.

YOU became taller last year even if you didn't grow a bit. And you got heavier, too, even if you didn't add any flesh or bone to your body.

There was a change in the way English-speaking nations describe height and weight. The inch grew shorter and the pound less heavy. Thus there are a greater number of the new inches in your height and more of the lighter pounds in your weight.

To be sure, the differences are very, very small. A six-foot man gained only 1.4 thousandths of an inch. A 150-pound boy put on only 37 millionths of a pound.

In our daily lives this is nothing to get excited about, perhaps. But to scientists the changes mean that for the first time in history, the six English-speaking nations of the world—the United States, Britain, Canada, New Zealand, Australia, and South Africa—are united in what the terms inch and pound mean.

Now the inch equals 2.54 centimeters instead 2.540005 centimeters, set by Congress in 1866. The new pound weighs 453.59237 grams instead of 453.5924277 grams.

Insignificant, you say? Emphatically not, reply the scientists. For it is in regions of the very tiny or the very large that most important scientific discoveries of the world have been made. Albert A. Michelson, the brilliant American who won the Nobel Prize in physics in 1907, once said: "The future truths of physical science are to be looked for in the sixth place of decimals."

Nearly all the greatest discoveries of science have been the rewards of accurate measurement.

Accuracy in measurement aids in discovery. Johannes Kepler, the German astronomer (1571-1630), discovered the three important laws of planetary motion that bear his name. He built a better telescope to study the stars and planets. By seeing that there were unexplained differences between where a planet should be and where it actually was observed, he opened the door for a correct picture of our solar system. His work helped to change the notion that the Earth was the center of the universe.

Importance of Accuracy

Michael Faraday, the English chemist and physicist (1791-1867), probed into the almost immeasurable regions of electricity. He found that if a wire is moved past a magnet, a very tiny electric current flows through the wire. This discovery made possible the dynamos that light our world.

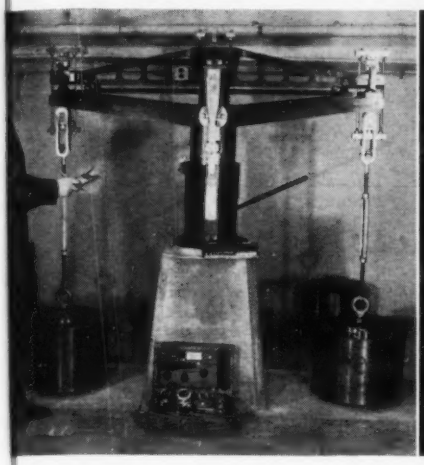
Only through accurate measurement can we understand many of the events of nature.

Measurement was among man's first mental achievements. Anthropologists tell us that man made rough measurements of the length of his spear or the size of his land many centuries before he learned to write and read.

The width of his first finger was a "digit," the ancestor of our inch. A "hand" was the width across a palm; even today horse traders measure the height of a horse in "hands." From the tip of a man's nose to the end of his fingers was a yard. The length of a human foot was called a "foot."

But few persons have the same

Watchdog of Our Weights and Measures Is National Bureau of Standards



Standard balance kept at the bureau in Washington, D. C., can weigh 1,000 lbs. with accuracy of one part in million.

Platinum-iridium cylinder 39 mm. high, 39 mm. in diameter is national standard of mass. Copy came from France in 1876.

National Bureau of Standards

Balance compares weights with standard weights for microbalance. Accuracy is maintained to one ten-millionth of gram.

finger width or foot length. So two persons would seldom have the same standard.

Kings tried to standardize weights and lengths, but were unsuccessful. A Chinese emperor could build the Great Wall, but he failed to standardize measurement. Rome, for all its glory, had six different lengths that were called a "foot." Charlemagne, William the Conqueror, Henry VIII, Talleyrand, and other great men failed.

Barley Corns End to End

Eventually a British King, Edward II, saw that barley corns were more uniform than the feet of people. He ordered the inch to be "three barley corns, dry, round and laid end to end."

We should not laugh too much at Europe's fumblings, however. In Brooklyn, in 1902, four lengths were legally called a foot. They measured 10, 13, 17, and 27 inches—depending on which one you chose. If you were selling lumber by the foot, you used the 10-inch length. If you were buying lumber, the 27-inch length, naturally.

Weight measurements were only slightly less chaotic. The Egyptians used the weight of a seed of grain as a standard. They called this a "grain." They also used a "pound" as a weight unit of money. The British used "stones."

Pound is still used, of course, even as British monetary units. Grains are used in chemistry; 7,000 grains equal a pound. And the British continue to measure weight in stones. A 150-pound man weighs 10.7 stones.

Scientists soon discovered that what we usually call weight is really mass. Mass is the amount of material in an object, whether it be our bodies or blocks of wood. Weight is the force the Earth exerts in pulling the mass toward its center. At sea level, mass equals weight. A man weighs 200 pounds at sea level if his mass is 200 pounds.

But as we leave Earth, the difference between mass and weight becomes pronounced. At 10,000 feet, our 200-pound man weighs 199.8 pounds. On the moon, which has a weaker pull, he would weigh 33 pounds. In outer space, it is believed, he would have no weight. Yet in every case his mass remains 200 pounds.

It was long obvious that the English system of weights and measures was inadequate for scientific research. This was true even after many units had been standardized so that they meant the same thing. A unified system was needed.

The ideal system should have simple measuring units. These basic units should not vary whenever and wherever they are used. Further, they should describe some relationship between weight and length.

The metric system meets these requirements. Yet the French scientists who created this system during the French Revolution were often in danger—for political reasons.

Earth and Water

The metric system depends on only two quantities—the size of the Earth and the weight of water. The basic unit of length is defined as the meter—one ten-millionth of the distance from the North Pole to the Equator along the Earth's surface. The meter has recently been defined more precisely. It is now the distance between two lines on a bar of platinum-iridium (at zero degrees Centigrade). This bar is kept in the International Bureau of Weights and Measures at Sevres, France. A meter equals 39.37 inches, or a little more than a yard.

For longer lengths, the unit is the kilometer, or one thousand meters. This is about five-eighths of a mile. For shorter lengths, the meter is divided into hundreds and thousands. A hundredth of a meter is a centimeter. A thousandth of a meter is a millimeter. Even smaller is a micron, or a millionth of a meter.

Weight is measured in grams. The fathers of the metric system made a small container. It was one centimeter high, one centimeter long, and one centimeter wide. This is a cubic centimeter. They filled it with pure water. The weight of the water they called a gram. There are 453.59237 grams in a pound.

National Bureau of Standards

National standard of length is meter bar of platinum-iridium. It was taken to France in special carrying case for comparison with the international standard.

For heavy weights, a kilogram is the unit of measure. It is one thousand grams. For lighter weights, the gram is divided by thousands (milligram) and millions (microgram).

Measuring "Color"

Practically every scientist in the world agrees that the metric system is better for scientific research than the English system. Although the ultimate gains would be very great, many people believe it would be too costly to change over all our yardsticks, measuring cups, and scales, at this time. So the world goes along with needless duplication of measurement systems.

The best microscope in the world today will show us particles that are 0.000002 inches long. One of the smallest particles science knows, the electron, is 0.0000000000001 inches in diameter. You could squeeze 10 trillion of them into an inch. No one has ever seen or measured an electron directly.

The smallest unit for measuring length is the Angstrom unit. It is a hundred millionth of a centimeter. Its primary use is in the measurement of light waves. Different colors of light have different wave lengths. We see the color red, for example, when light waves 7,600 Angstrom units long strike our eyes. Violet, at the other end of the color range, or spectrum, is caused by waves 3,850 Angstrom units in length.

Each color has its own spectrum of wave lengths. Every substance sends out a distinctive spectrum of wave lengths when it is heated. On the other hand, every substance absorbs the same distinctive spectrum of wave lengths when radiation hits it. This behavior has been turned into one of chemistry's most important tools of analysis. The tool is called spectroscopy. It works something like this:

When radiation of all wave lengths is directed into a mixture of gases, an individual gas in the mixture absorbs only its own special wave length. All others pass through. By determining which wave lengths come through, chemists identify the gases present in the mixture.

Astronomers make use of spectroscopy, too. They watch light that comes through clouds around planets to learn the composition of the cloud and the planet. In this way they have determined that the clouds enveloping Venus consist primarily of carbon dioxide, even though that brilliant planet is more than 20,000,000 miles away from their instruments.

Besides length and weight, man must measure time to get an accurate description of nature. Time is measured in seconds. But what is a second? How long is a second, or a microsecond (a millionth of a second), or a micromicrosecond (a million millionth of a second)?

Shortest Time Interval

A second is the time it takes light to travel 186,160 miles. And a microsecond is about the fastest that the shutter of the best camera can snap. And a micromicrosecond is about the time it takes for an atomic core to split apart.

Nuclear physicists tell us about the shortest time interval in the universe. It is the time it takes for a sub-atomic particle to jump in and out of the nucleus: one billion trillionth of a second. This is also called one thousanth of a micromicromicrosecond.

Throughout history time measurements have been vital to man. Prehistoric farmers needed to know when to plant crops. So time was divided into years, months and days. A day was the time interval between the rising and setting of the sun. Babylonians counted by sixes, instead of tens as we do now. So the day was divided into multiples of sixes: 24 hours in a day, 60 minutes in an hour, 60 seconds in a minute.

In this system, the second was calculated from the movement of the

National Bureau of Standards

Blocks used to set dimensions in manufacturing missile components are measured to accuracy of one part in million.

sun, the stars, and the planets. A calendar was devised from the observation that the sun" "appears" to move each day and seems to return to the same "apparent" spot in the sky the next day.

Measuring by Stars

This calendar was incorrect. There were many small errors of measurement. However, the errors were not noticed for 1,500 years. It then became obvious to atronomers that calendars had lost ten days in 1,500 years. This error was corrected partially by moving the calendar ahead ten days.

Men began to look for a new way to measure time. The stars appeared "fixed" in their place. Until recently they were the most reliable way of measuring time. The Naval Observatory in Washington still sends out accurate time signals based upon its observation of the stars.

But scientists needed a truly standard second for their work. After all, the speed of light is 186,160 miles a second. An error of one per cent in the length of a second means an error of 1,861 miles in calculation.

Scientists found a very precise way to measure the second by the vibrations inside molecules. An ammonia molecule, in particular, vibrates at a very constant rate. It is made up of three atoms of hydrogen, arranged at three corners of a pyramid, plus one nitrogen atom at the apex. The nitrogen bounces "up" and "down" 23,870,100 times a second. So a second is now defined using this "atomic clock." It is the time it takes for 23,870,100 vibrations in the ammonia molecule.

As man inquired deeper into nature, he discovered invisible things that affected him. He was warmed by fire during cold nights. But how hot was the fire? How did it warm him?

The ancient Greeks knew that heat caused air to expand. But it wasn't until the sixteenth century that Galileo Galilei (1564-1642) invented the first thermometer.

Gabriel Daniel Fahrenheit (1686-1736), a German physicist, thought that nothing could become any colder than very salty water, which he made the zero point on his scale. On his scale, pure water freezes at 32 degrees Fahrenheit (F), man's body temperature is about 98.6 degrees F, and water boils at 212 degrees F.

Measuring Heat and Cold

Anders Celsius (1701-1744), a Swedish astronomer, invented the metric scale for measuring temperature, which we often call the Centigrade scale. On this scale the zero point is freezing temperature of pure water, and the boiling point of water is 100 degrees Centigrade (C).

Today, however, we need to describe temperatures which go far below zero on any Fahrenheit or Centigrade scales. There are a few scales based on absolute zero, the coldest temperature on Earth. Absolute Zero is −273.15 degrees C. or −459.6 degrees F.

Some of the most fascinating phenomena in science occur near absolute zero. For example, oxygen, which we know as a gas, becomes a liquid at −183 degrees C. and a solid at −227 degrees C. Liquid oxygen (lox) is one of the ingredients of certain rocket fuels.

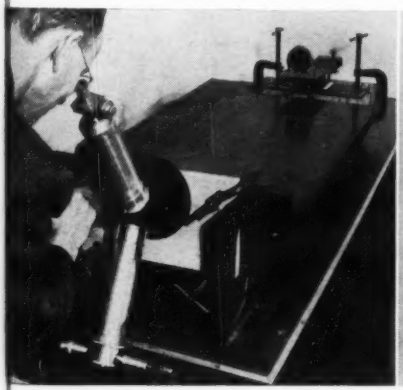
Whether you become a scientist or a citizen interested in science, an acquaintance with the terms of measurement will always be useful to you. New units of measurement are being invented today. They are indications of great forward strides.

Measuring "Strangeness"

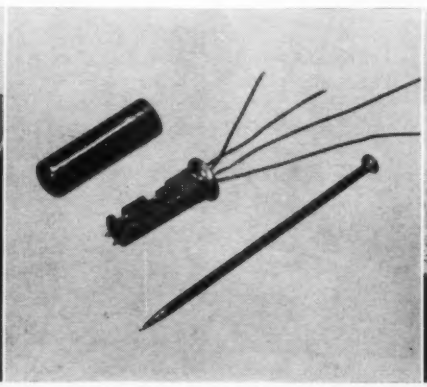
In Washington this summer, science advisors to President Eisenhower suggested new uses for huge atom smashers. With them, man might at last find the connection he has long sought between the inner space of the atom and the outer space of the universe. As atom smashers probe deeper into the heart of the atom, it may become necessary to revise our concepts of space and time. "The practical results that must derive from continued exploration with larger accelerators cannot be guessed," the scientists said. "The one thing that we have learned to expect from nature is to be surprised."

However, future scientists will have to go some to top the latest measuring unit. It is the "strangeness" unit, invented to describe the degree of non-conformity of particles smaller than an atom's nucleus.

These Instruments Measure Smoothness, Temperature, and Stress



Instrument developed by bureau tests flatness of large surface. Fringes in the eyepiece are clue to surface flatness.



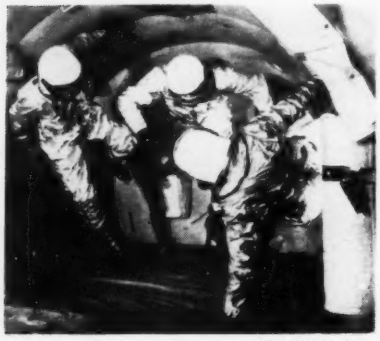
Bell Telephone Labs

Thermometer, tinier than pin, measures temperatures close to absolute zero: −459.6 F., the coldest known to man.

National Bureau of Standards

Instrument tests stress, applying force to an area. Results are shown on oscilloscope *(left)* and graph paper *(right)*.

Science in the news



Wide World photo

Three astronauts (of seven in training) tumble about padded cabin of plane, training for weightless flight. They wear pressure suits over air-conditioned inner suits. Cost of each suit: $3,500.

Spacemen Progress

The seven U. S. spacemen—our Project Mercury astronauts—have been in training all summer. In 1961 one of the seven may be the first American to orbit the Earth. He will strap himself in a one-ton space capsule and be bulleted into orbit around Earth at a speed of 18,000 miles per hour.

At blast off, an invisible "fist" will smash against the astronaut's body. This will be gravity trying to clutch him back to Earth. As part of their training the astronauts have been subjected to 25 times the pull of normal gravity, created by whirling them in a huge centrifuge.

Once in orbit the astronaut will be in "free fall." If he weren't strapped down, he would float about the cabin. For this part of their training, the astronauts have been subjected to zero gravity and the accompanying condition of weightlessness.

Weightlessness occurs when there is no resistance to gravity. This condition can be created for about half a minute in a plane by pulling it out of a dive, cutting off the engine, and having it describe an upward arc.

Space Monkeys

Two female monkeys named Able and Baker made history this summer by being flown 1,500 miles through space in 15 minutes. They were picked up by a Navy tugboat in the Caribbean, one hour and 33 minutes after being launched at Cape Canaveral, Fla., in a space capsule. Their speed: 10,000 miles an hour at an altitude of 300 miles. For nine minutes of flight the monkeys were weightless (*see story at left*).

Electronic instruments radioed back information on how the monkeys reacted to the space test. Electrodes planted in the monkeys kept tabs on heart condition, pulse, respiration, and temperature. Space medicine experts reported that physiological changes during flight were very slight.

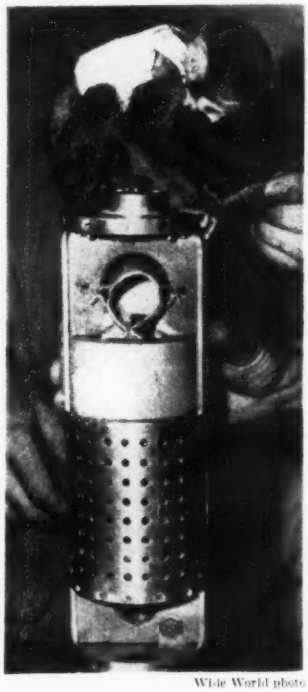
Heartbeats of the monkeys accelerated as the missile took off and increased its speed. Heartbeats and respiration returned to near normal during flight, then speeded up again as the missile fell from its top altitude.

Hailed as the first animals to survive space flight, the monkeys were brought before a battery of newsreel cameras. Under klieg lights, the temperature exceeded 100 degrees, higher than the greatest heat in the monkeys' capsule during flight—84 degrees.

In a minor operation to remove the electrodes, one-pound squirrel monkey Baker survived. Able, a seven-pound Rhesus monkey, did not. Able's death was not caused by the space flight, but by anesthesia. Efforts to revive Able included mouth-to-mouth respiration, cardiac massage, and electric shock therapy.

Meanwhile, other monkeys are being prepared for brief rocket rides. The animal program is called "Little Joe."

The Navy plans to find a mate for "Miss" Baker. Space medicine experts are eager to learn whether her offspring will show abnormalities due to their mother's exposure to cosmic radiation.



Wide World photo

Space monkey Baker sits on space capsule she used on historic trip.

X-15 Takes a Test

The X-15 rocket plane, which may be the vehicle for man's first penetration to the edge of the atmosphere—100 miles above Earth—and into space, performed perfectly on its first free flight this summer over the Mojave Desert in California.

Test pilot Scott Crossfield was at the controls of the 50-foot, bullet-shaped X-15, designed to fly at speeds up to 4,000 miles an hour at altitudes of 100 miles or more.

The flight was an unpowered five-minute glide to Earth from an altitude of seven miles after the X-15 had been released from its B-52 "mother" ship.

When the ship climbs into the lower reaches of space some time next year, traveling faster than a mile a second, there will be a doctor along—by remote control.

To guard against the unknown, to warn the busy pilot he may be near the limits of physical endurance, and to help collect vital information on the pilot's reactions, a flight surgeon always will have him under observation—through radio instruments.

UPI photo

Rocket-powered X-15 glides at 38,000 feet over California desert. Test pilot Scott Crossfield is at controls. Ship is to attempt flight to edge of atmosphere.

UPI photo

TOMORROW'S SOLDIER—GI models uniform featuring infra-red binoculars, two-way radio helmet, radiation-proof face mask, explosive charges for digging foxholes, jump belt, and M-14 rifle.

Moon Seismograph

What is the moon made of?

About six years from now we may get an answer to this age-old question about the composition of the moon. Scientists are planning to place a seismograph on the moon. This apparatus will register the shocks and vibrations of the moon's crust. An answer to the question: "Do moonquakes occur?" will uncover some of the moon's secrets, and also tell us more about the relationship between the Earth and the moon.

Dr. Maurice Ewing of Columbia University's Lamont Geological Observatory and Dr. Frank Press of the California Institute of Technology (a former student of Dr. Ewing) will direct the project. It is sponsored by the National Aeronautics and Space Administration.

With a lunar seismograph, Dr. Ewing explained, we may expect to find out what kind of rock the moon is composed of; whether or not the interior is molten; whether shifts occur on the moon's crust to cause quakes like those that take place on earth; what the dust and rubble on the surface of the moon are made of; and information about the size, velocity, and distribution of meteoric particles in space.

It is expected that the lunar seismograph with its delicate telemetering apparatus will weigh less than 20 pounds.

Drilling to the Moho

What's inside the earth?

Scientists have long believed that if they could drill deep enough they might find the answer to this and many other questions. Some of the questions: What is the interior of the earth made of? How did the earth originate? Is the earth cooling down or warming up? What causes earthquakes? Is there any fossil record of the first billion years of life on earth, a period to which we have found no clues?

This summer scientists surveyed the bottom of the sea north of Puerto Rico, probing for a place to drill. They are now studying their findings.

Why sound the seas in order to drill into the earth?

The earth is made up of four principal layers. On the outside is the crust. Under the oceans the earth's crust is thinnest. It is especially thin—less than three miles thick—north of Puerto Rico. Under the continents the crust averages about 25 miles in thickness.

Beneath the crust is the mantle. This is about 1,800 miles thick and makes up 80 per cent of the earth's bulk.

One of the first scientists to explore the mantle was a Yugoslav named A. Mohorovicic who was studying earthquakes. An earthquake sends vibrations through the body of the earth. These vibrations are recorded by instruments. In 1909 Mohorovicic found that these vibrations, or waves, were of two types. One traveled in straight lines, like ripples in a pond when you toss in a pebble. The second type of wave was distorted. It moved at right angles to the first.

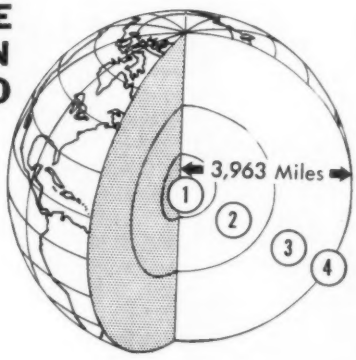
Mohorovicic reasoned that the earthquake waves were being bent out of line by a break in the earth's structure between the crust and the mantle. This break is called the "Mohorovicic Discontinuity"—Moho for short. The proposed hole has been dubbed "Mohole."

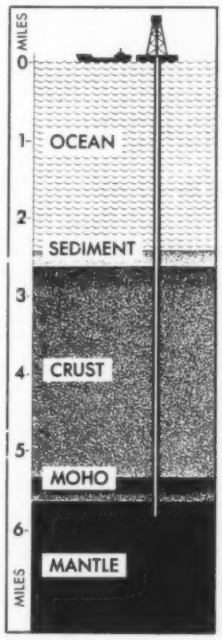
Finally, within the mantle is the earth's central core. This is believed to consist of an inner core and an outer core.

Scientists expect to drive their drill seven miles into the earth. This would make Mohole the deepest hole in the world. (The deepest oil well, sunk last year in Texas, goes down only about four miles.) Earth samples brought up at various depths would provide a history of early forms of life and the climates in which each developed. It would be like reading a history book backward, with the last samples going back about a billion years.

Biggest problem in drilling will be heat. The temperature of the rock will be so hot (about 600 degrees F.) that the rock might flow back into the hole like mud. At the bottom of the Texas well the temperature was 350 degrees, hot enough to melt some metals.

MORE ON MOHO





Cross section diagram at right shows how earth would look if sliced straight down at the ocean north of Puerto Rico. Barge on surface would carry equipment for drilling Mohole.

Diagram above shows layers of the earth.

1. **Inner core (may be solid iron and nickel).**
2. **Outer core (may be iron in semi-liquid state and nickel).**
3. **Mantle, 1,800 miles thick (probably hot rock).**
4. **Crust, 3 to 40 miles thick (rock and earth).**

Science in the news

Explorer VI

Explorer VI, a 142-pound satellite crammed with scientific instruments, was launched from Cape Canaveral, Fla., on August 7. It is expected to have a lifetime of at least one year.

Hurled into space by a three-stage Thor-Able rocket, the satellite's elliptical orbit (*see diagram*) reached more than 25,000 miles into space. It was only 150 miles from the Earth at its closest point, and took twelve and one-half hours to complete its orbit.

The sphere, 26 inches in diameter and 29 inches deep, had an unusual appearance. Four paddles, 20 by 20 inches each, jutted from the sides. The paddles were studded with solar cells—a thousand on each side. These cells convert sunlight into electricity. The electricity, in turn, recharges chemical batteries inside the satellite.

Jammed into the satellite's shiny shell was apparatus designed to answer a number of questions. These fall into six major groups:

Radiation Belts—How deadly are the atomic particles trapped in the radiation belts surrounding the Earth? Where do the particles come from? Two radiation belts were discovered by earlier satellites. One is about 2,000 miles above the Earth. The other is 10,000 miles away. Explorer's orbit pierces the outer belt of radiation and swings far beyond it. The satellite should be able to map the extent and intensity of these belts.

Radio Signals—Is electronic communication possible at distances of 25,000 miles and beyond? What makes up the ionosphere? How does it reflect and distort the paths of radio waves?

Magnetic Field—What is the size, shape, and direction of the Earth's magnetic field? How is it disturbed by bursts of electrified gas spewed from the sun? Why do the resulting magnetic storms upset electronic communications on Earth, and cause northern lights to flash across the Arctic sky?

Television Scanning—What does the Earth and its cloud cover look like from space? A device similar to an elementary television camera will record light and dark impressions, and convert them into radio signals.

Micrometeorites—How large are micrometeorites (cosmic dust)? How fast do they travel? Two shiny metal plates below Explorer's waist will detect impact of meteoric particles. A microphone behind each plate will record each collision as a voltage signal. This will be transmitted to Earth.

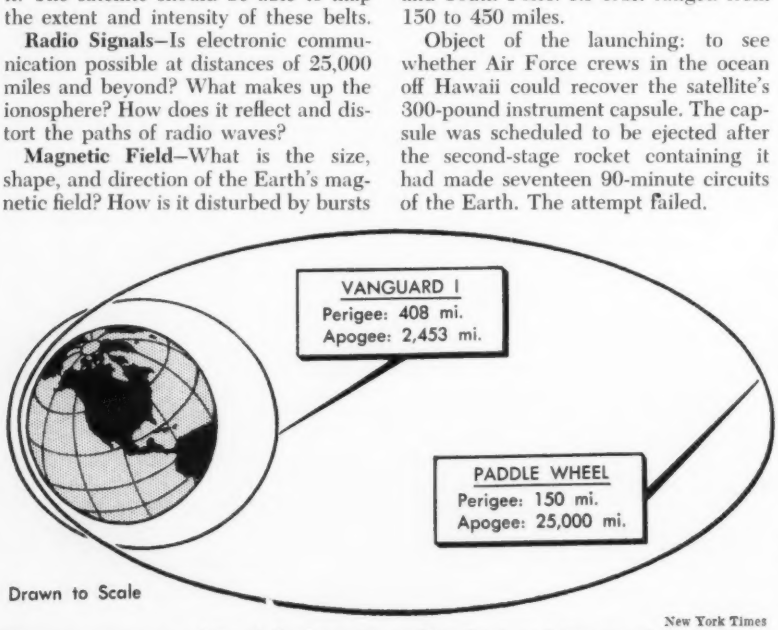
Solar Power—Can solar energy be used successfully to power instruments in space vehicles?

Three radio transmitters aboard Explorer VI are sending back scientific information. The satellite also carries two radio receivers. One picks up command signals sent from the Earth. The other studies low-frequency radio waves transmitted from the Earth.

Explorer VI ushers in the "second generation" of more complex, heavier satellites.

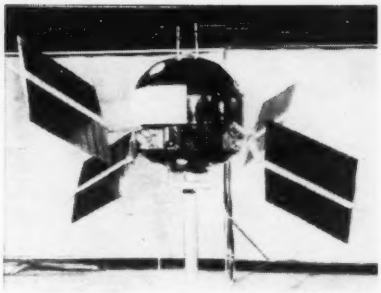
A two-stage Discoverer satellite was sent into orbit August 13 from Vandenberg Air Force Base, Calif. It was aimed southward into a path over the North and South Poles. Its orbit ranged from 150 to 450 miles.

Object of the launching: to see whether Air Force crews in the ocean off Hawaii could recover the satellite's 300-pound instrument capsule. The capsule was scheduled to be ejected after the second-stage rocket containing it had made seventeen 90-minute circuits of the Earth. The attempt failed.



New York Times

Diagram compares orbits of Explorer VI paddlewheel and Vanguard I satellites.



UPI photo

Four paddles of Explorer VI satellite were folded back at launching, then sprang out as above. Solar cells on paddles make electricity from sunlight.

Radio "Sees" A-Shots

Nuclear explosions and rocket launchings can no longer be kept secret. More than 95 per cent of these "shots" can now be detected instantaneously by a single radio scanning station in the United States.

Name of the new device is "Project Tepee." This does not refer to an Indian dwelling. T. P. stands for "Thaler's Project." Dr. William J. Thayler, 33-year-old scientist, devised the new detection system for the Navy.

How does Tepee work?

The exhaust of a rocket or the blast cloud of a nuclear bomb are good reflectors of radio signals. The molecules in a rocket propellant, like those in the air around a nuclear blast, are torn apart by the explosion. Particles called ions, charged with either negative or positive electricity, are created. These ions reflect radio signals.

High-frequency radio signals from the new detection system are bounced off these ions. The radio signals are sent around the globe by reflecting them off the ionosphere. The ionosphere is the region of our atmosphere extending 50 to 500 miles above the Earth.

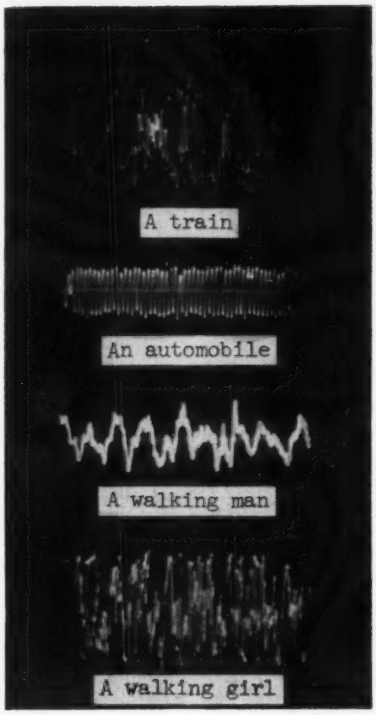
Unlike radar, Tepee permits a view over the horizon. Radar cannot "see" beyond the curvature of the Earth. The new system circles the globe instantly.

Plant Growth

Chemical sleuthing has yielded a new class of substances which promote plant growth. These new chemicals are more powerful than the most widely known plant growth stimulants.

This discovery may shed new light on the complex nature of plant growth. Such information will be of great importance. Powerful weed-killers are based on growth-regulating chemicals.

The research leading to these new chemicals was started five years ago by



U. S. Army photo

New Army radar tells differences in targets by sound and radar screen. It can spot slightest move behind enemy lines, tell whether a man or woman is walking.

D. G. Crosby of Union Carbide Chemicals Company and A. J. Vlitos of Caroni, Ltd., Trinidad, B. W. I. They studied a tobacco plant called Maryland Mammoth because of its unusually large growth. It was thought that this excessive growth might be caused by some unknown compounds. Laborious chemical detective work produced ten grams of these unknown compounds from a ton of tobacco leaves and tobacco tips.

The two researchers used paper chromatography to analyze these compounds. Paper chromatography consists of placing a drop of liquid near one end of a strip of paper. This end is then immersed in solvent, a liquid that will dissolve it. The solvent travels along the paper and distributes the chemicals present in the original drop. Each chemical shows up in a separate zone of the paper. The chemicals are identified by comparing them with known substances. (*Science World* will carry a complete article on chromatography in a forthcoming issue.)

One of the two substances isolated was a compound called 1-docosanol, a member of the fatty alcohol group of compounds. The other chemical, a fatty acid, has not yet been identified.

From the detective work of these two plant scientists may come new understandings of plant growth.

New Culture Medium

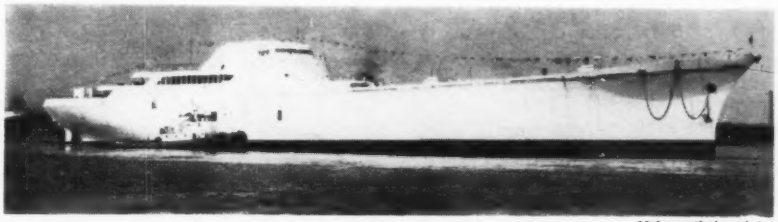
Can the uncontrolled growth of malignant cells be arrested by changing their diets? Can these cells be destroyed by poisons designed to kill cancer cells?

Cancer researchers may be able to find the answers to these questions as the result of research by Dr. Charity Waymouth of the Roscoe B. Jackson Memorial Laboratory, Bar Harbor, Me. She has discovered a combination of chemicals that will support animal life in a test tube. This will enable scientists to learn how nature uses vitamins, amino acids, simple salts, glucose, and other substances to produce the complicated chemicals that support life.

Before Dr. Waymouth's discovery, it was necessary to use blood serum or embryo juices to sustain animal life in a test tube. Both of these culture media contain many unidentified chemicals. Dr. Waymouth's medium contains specific, *known* chemicals.

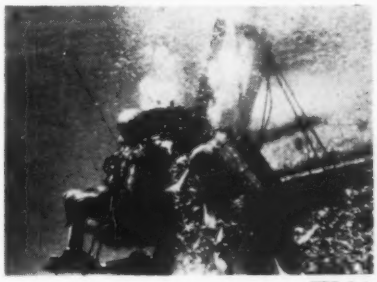
For seven years Dr. Waymouth has been growing mouse cells on forty simple compounds. These have included dextrose, nine vitamins, and ordinary table salt. The cells have increased seven- or eight-fold each week, comparable to natural growth.

This contribution to biology will enable scientists to make precise studies of the basic chemistry of life. (*See "Our Tiniest Chemical Laboratory," pp. 9-11 this issue.*)



Molesworth Associates

First atomic powered merchant ship, *NS Savannah*, rides sleek and glistening in Delaware River after launching by Mrs. Eisenhower. Cost: $40,000,000. About 690 lbs. of enriched uranium will take ship 15 times around world without refueling.



UPI photo

What happens to pilot in an air crash at sea? *Top:* Navy F9F plunges in test. *Bottom:* Diver studies dummy to learn how to improve the ejection mechanism.

(In a future issue *Science World* will bring you a feature article on the research done at the Roscoe B. Jackson Memorial Laboratory.)

Live Polio Shots

More than 4,500,000 persons have been immunized by a live polio vaccine developed by Dr. Albert Sabin of the University of Cincinnati. This large-scale test was carried out in the Soviet Union, Poland, Czechoslovakia, Mexico, and Malaya.

The tests show that one dose of the live vaccine may eventually give lifelong protection from the three known types of polio. The live vaccine may be taken by mouth at about one tenth the cost of Salk vaccine. (*See "Polio Fighter," p. 20 this issue.*)

The U. S. Public Health Service has announced, however, that for the present it will not license a live polio vaccine. It said more controlled studies were needed.

One of the questions to be answered: Can the weakened virus change to a wild and dangerous type of virus after passing through the digestive tract, thereby setting off an epidemic?

In the meantime, the National Foundation has recommended the formation of a committee of American scientists to study the present tests. In the near future, we may have still another powerful weapon with which to combat polio.

National Foundation photo

Salk tests the purity of his vaccine.

today's scientists

JONAS SALK . . . Polio Fighter

"ARE YOU AND YOUR FAMILY PROTECTED FROM CRIPPLING POLIO! . . . Would YOU ever forgive YOURSELF if a member of your family were crippled by polio because he had not been vaccinated?"

This dramatic message was part of a four-page leaflet distributed recently by the health department of many large cities. The message urges you to get polio protection!

Six years ago there was no polio protection. Today a dreaded disease which twists and mangles its surviving victims is on its way to being wiped out.

Hundreds of scientists have contributed to the success of the polio vaccine, but one man's work is particularly outstanding. His name is Dr. Jonas Edward Salk. It was he who tied together many threads of earlier research and discovered how to make the vaccine.

What is Dr. Salk's reward for a discovery that may save your life? He has no patent or rights of ownership to the successful formula. He does not receive any royalties from the manufacture and sale of the vaccine. Had Dr. Salk invented a new potato peeler he might have made a fortune. His discovery of a vaccine to permit men, women, and children to live without fear of a paralyzing disease made only newspaper headlines.

What does it take for a man to spend five years at selfless research—often working around the clock?

Drawn to Research

Jonas Salk was born in New York City in 1914. At 19 he was graduated from the College of the City of New York. He studied medicine at the New York University College of Medicine.

After a two-year hospital internship, Jonas Salk decided to go into research. This decision is one for which the world can be grateful. Armed with a fellowship for work on viruses, he went to Ann Arbor, Michigan.

In 1947, Dr. William S. McEllroy, the University of Pittsburgh's dean of medicine, was looking for a bright young virologist to start a virus laboratory. Dr. Salk was tapped for the job. He soon decided to join the search for a polio preventive.

A great discovery in any field is *never* made alone. It reflects the work of many people. It is the bringing together of years of previous thinking, exploration, observation, and experimentation. This work is published in scientific journals for all to see, confirm or disprove. Often this work is picked by another researcher and expanded or altered.

What events led to Dr. Salk's discovery?

Tracking Down the Clues

One was the discovery, 50 years ago, by Dr. Karl Landsteiner, that polio was caused by a virus. (A virus is so tiny scientists are not sure whether it is a living organism. However, it can survive only in living organisms.) Scientists toiled along this line. Then, only 10 years ago, Drs. John F. Enders, Thomas H. Weller, and F. C. Robbins experimented with growing the polio virus in a test tube on non-nerve tissue. They succeeded.

At the same time, Drs. Howard Howe and David Bodian reached a conclusion concerning immunity to the polio virus: *all known strains of polio virus belong to three types.* If this could be proved without doubt, then *one strain of each type* would be all that is needed in a vaccine. Four universities, including the one at which Dr. Salk worked, were commissioned by the National Foundation to classify one hundred strains.

Meanwhile, research by other investigators continued. Drs. David Bodian and Dorothy Horstmann discovered that the virus circulated in the victim's blood stream before going on to damage the nervous system. Since vaccines work in the blood, if the virus could be killed there by antibodies there would be no chance for the virus to do any damage.

It took three years for Dr. Salk and his staff to type 74 strains. During this time, Dr. Salk became interested in Dr. Enders' tissue culture technique. He began to work on ways to improve the technique.

Dr. Salk's first problem was to find the most useful virus-growing tissues. He found the kidney of a monkey best for his purposes. Next came the problem of finding the best broth in which to grow the tissue cells. This meant more research and testing. Finally one was selected. It had been developed by Dr. R. C. Parker of Toronto and was being used by him for culturing cancer cells.

Now it was necessary to find the best way of killing the virus with formaldehyde solution. Dr. Salk and his staff tried various temperatures and concentrations until the right one was found.

Dr. Salk now had the ingredients for a polio vaccine. He had found substantial proof that only three types of virus were needed for a vaccine. He had a large amount of virus which had been grown in non-nerve tissue. Lastly, he knew how to kill the virus while leaving it with the ability to stimulate the formation of protective antibodies within the human body. His last step was to find the level of antibodies needed to assure polio protection.

Monkeys were used to test the experimental vaccines which Dr. Salk had prepared. When he was convinced that the vaccine was safe enough, he decided to try it on human beings.

Test in Nationwide Lab

His first subjects, as a safety precaution, were polio victims who had recovered. Once someone has had polio, he usually builds up immunity to it. Vaccine injected into such a person should raise his antibody level. This rise Dr. Salk could measure. If the vaccine produced a booster effect, the vaccine worked. The booster effect was produced!

Dr. Salk had shown that his killed virus vaccine could stimulate antibody formation. Now came the real experiment! Thousands of children were given the vaccine in a tremendous field test.

In 1955 the news for which the world was waiting was announced: the vaccine was up to 90 per cent effective!

Thank you, Dr. Salk.

tomorrow's scientists

Project: Light Sensitivities of the Earthworm

Student: **Nancy Sahnd**

Walnut Hills High School

Cincinnati, Ohio

Science Achievement Awards Entry

Teacher: **Gordon Woodward**

[Have you ever gone hunting for earthworms or night crawlers? On a dark, damp night you can see them sticking out of their burrows. Then, all of a sudden, they are gone. Was it a noise, a shock, a flash of light or something else that caused them to pop back into the ground? Nancy Sahnd of Walnut Hills High School, Cincinnati, Ohio, decided to find the answer. Here is Nancy's description of her science project.]

Light source for testing earthworms. Spout of oil can brings light to point.

SINCE my father's hobby is raising earthworms, I noticed many things about them which made me curious. For example, although an earthworm looks pretty much the same from one end to the other, I have wondered whether one part of it might be more sensitive to light than the other parts.

To carry out my investigation, I needed only some very simple equipment and an uncomplicated procedure. Here are the problems I encountered and the way in which I solved them.

Problem 1

To construct a "light pencil" by which a point of light could be directed to small areas of the worm's body.

Solution

I made this from a pocket pen light which uses two Eveready #915 AA batteries. I attached the spout top of an oil can over the end of the light bulb. *(See photo.)*

Problem 2

To arrange about 25 worms, each in a separate container, so that I could test each worm at least 10 times and give it a rest between each test.

Solution

I found a plastic ice cube tray with individual lift-out compartments. I sprayed the tray black, so that no light could be reflected, labeled each compartment, and covered the tray with cardboard.

Problem 3

To have a simple system for labeling the compartments, enabling me to use both red wigglers (which my father raises) and night-crawlers.

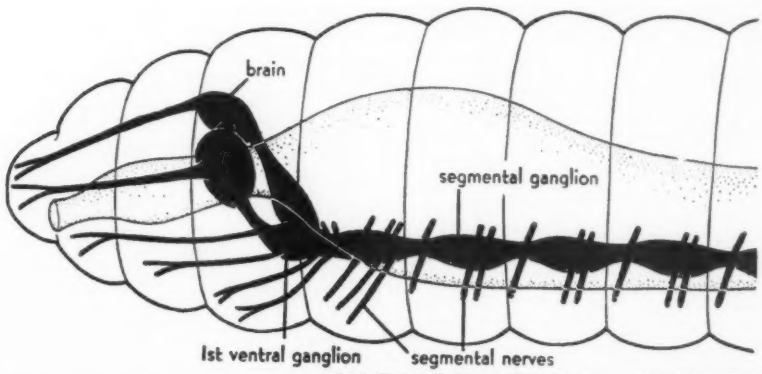
Solution

(A1–A20) "A" indicates red wiggler; the number indicates the worm. (B1–B20) "B" indicates night-crawler, the number indicates the worm.

These worms were tested in the following manner: Using the light, I explored the skin surface of dark-adaptive worms in order to find the special areas that were most sensitive. (Tail, head, sides, etc.) In a dark room, I placed A1 on a piece of wet paper toweling. I tested its sensitivities with my pen light. This was continued with A2, B1, etc.

When light was applied to the anterior end of the worms there were

(Continued on page 22)



Animals Without Backbones, Ralph Buchsbaum (U. of Chicago Press)

Diagram shows the "brain" and other parts of the nervous system of an earthworm.

Project: Are Plants Music Lovers?

Student: Marcia Riley

Old Massion Junior High School

Kansas City, Kansas

Science Achievement Awards Entry

Teacher: Leonard Molotsky

[Can music help plants grow? If your answer is yes, which kind of music gives the best results? Do these questions sound silly to you? They did to Marcia Riley of Old Massion Junior High School, Kansas City, Kansas. Marcia received the idea for her project from a science article pointed out to her by her science teacher, Leonard Molotsky. She did not find the idea of plants being "music lovers" very convincing, so she decided to find out for herself whether music could have any effect on plant growth.]

TO prepare for my experiment I got four phonograph records (33 1/3 speed) in four different fields of music. The first was "jazz," the second was "Dixieland," the third was "classical," and the fourth was a "sound effects" record.

PROCEDURE

The first four groups of plants were exposed to music, while the fifth was not. There were 10 plants in each group.

Bean plants were used in the experiment. All the beans were grown in glass jars (mayonnaise jars are excellent) with a piece of blotting paper in each. The beans were wedged between the glass of the jar and the blotting paper *(see diagram)*. The paper was soaked with water each day to keep the beans moist. If you fail to do this the plants will not survive. The jars were kept in a window where they received good sunlight.

TESTING

The plants were kept in almost complete silence except for being exposed to the music for one hour each day. They were then returned to the room where they were kept, and another group was brought out and similarly exposed to a different kind of music.

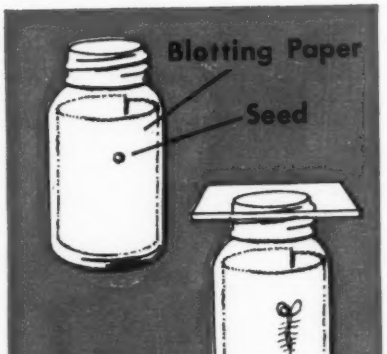
Every other day I measured the length of the leaf from where the stem goes into the leaf to the tip of the leaf, the width of the stem taken at the widest part of the stem, the number of leaves, the number of main roots, and the height of the plant taken from the tip of the longest root to the highest part of the plant. A meter stick and calipers were used for measurements.

Individual measurements of the plants in each group were recorded and totalled. I then averaged the measurements in various groups of plants. Three experiments were conducted, and the results came out approximately the same.

RESULTS

Of the four groups of music tested, the "sound effects" record seemed to have the most marked effect on the increase of plant growth.

The first group of experiments yielded results which were quite difficult to accept, so I ran the exact test over again, just in case the results might have been purely coincidental. However, the second results came out almost the same as did the first. I ran one more experiment, and was further assured that my results were accurate. The experiments lasted twelve days.



Beans grew in jars. Blotting paper was soaked with water to keep beans moist.

The classical music seemed also to affect the plants in a definitely marked way. The Dixieland was next and the jazz came in a poor fourth. These records were used: jazz—"Jazz Goes to College"; classical—Beethoven's "Emperor Concerto," performed by Robert Casadesus and the New York Philharmonic; Dixieland – "Lawrence Welk Plays Dixieland," by the Lawrence Welk Orchestra; sound effects—"Percussion in Hi Fi," by Dave Carolle.

[Marcia found that plants respond to certain types of music. Why don't you try out your record collection on your houseplants?]

Light Sensitivities of the Earthworm

Continued from page 21

violent reactions. They crawled rapidly, as if searching for a burrow. On a few occasions, the worms raised their anterior ends and tossed them from side to side. The reaction was instant.

There was little reaction when the sides were stimulated. When other parts of the body were illuminated, no effect was produced.

When I tried to draw some conclusions from my observations, I decided that the light must pass through the body of the earthworm. The cerebral ganglia (masses of nervous tissue) are located at the anterior or head end. Since the reactions at this point were most violent or instant, the light must somehow excite the cerebral ganglia after it penetrates the skin.

[Nancy hopes to continue her work with earthworms by testing them with various colored lights. She also expects to study further the separation of paired worms when exposed to light. Why don't you set up your own project to shed some new "light" on earthworms, and see how they react?]

Project: Metal Whiskers - - Their Growth

Student: **Michael Nolan**

Notre Dame High School
Chattanooga, Tenn.

Science Achievement Awards Entry

Teacher: **Sister Hyacinth**

[Have you ever seen whiskers growing on metal? You can, if you try Michael Nolan's science project. He first heard the little known term "metal whisker" from Dr. M. S. McCay of the University of Chattanooga. His enthusiasm aroused, Michael decided to see whether he could grow "metal whiskers." Here is his project.]

THE term "metal whisker" applies to any fibrous growth of a metal in either single or polycrystalline form with a high length to diameter ratio. These whiskers are not new in science. Fine metallic filaments were grown as early as 1877. Recently they have gained added attention because of their spontaneous growth from the platings of precision electrical apparatus, causing shorts and breakdowns in power supply.

GROWTH

Whiskers may be grown in several ways. A few of these are: (1) spontaneous growth of tin, zinc, or cadmium at room temperature. (2) Condensation of supersaturated metal vapor at a suitable temperature. This method works for zinc, mercury, or silicon. (3) Electro-deposition, a little known method, producing silver and copper growths of single-crystal filaments. (4) Decomposition or reduction with hydrogen of a metallic halide in a hot furnace. Specimen whiskers of copper, silver, iron, gold, nickel, cobalt, silicon, and platinum may all be obtained in this manner. Because this last method has been well described and works with so many metals, I chose to work with it.

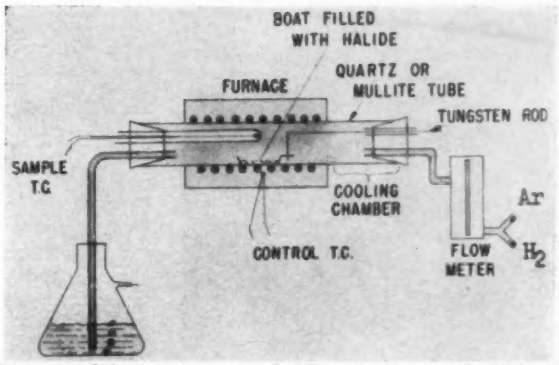


Diagram of the apparatus needed for growing metal whiskers.

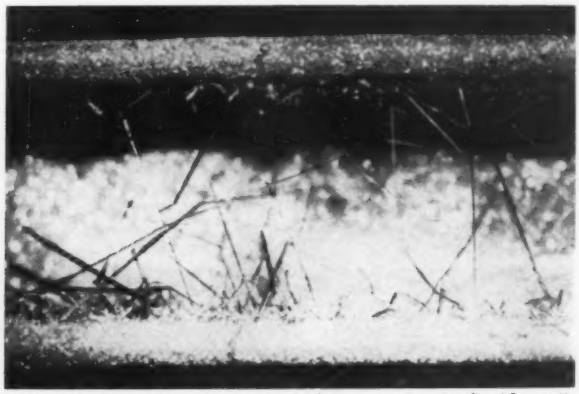
I will try to simplify Dr. G.W. Sear's and Dr. S. S. Brenner's explanation of this method: A metal is boiled until the vapor above the metal becomes supersaturated with particles of the metal. Some of the evaporated metal condenses on an imperfection on the still crystalline metal. Growth proceeds as additional metal atoms stick on the surface and then migrate to its tip.

At high supersaturation the whiskers are long and thin. However, if the temperature increases and the metal boils faster, they deposit faster, causing the filaments to become broad and kinked. At even higher temperatures, a homogeneous three-dimensional nucleation takes place, and the vapor is deposited more evenly over the surface in the form of octahedral particles.

PROBLEMS

My first problem was to obtain the materials needed to build the necessary apparatus. I knew I needed to heat metals to a high temperature, so I began constructing a furnace that would hold a tube or boat in which the metal could be placed. This container had to be not only fire-resistant, but also impervious to gases. I planned to heat a six-inch section of the metal by wrapping 6½ ft. of Nichrome electrical re-

Photo shows what iron whiskers look like magnified 60 times.



Enlarged photo shows copper whiskers growing in the "boat."

sistance wire around the fire resistant tube. The tube was 24 in. long and 1-⅛ in. inside diameter. This was insulated with asbestos, 2 in. thick, packed around it.

Another difficulty was controlling the heat of the furnace. After burning out a variable resistance box, I finally obtained a variac from the University of Chattanooga. The furnace operates off 115 volt line and draws a maximum of 3 amperes. Temperatures exceeding 800°C may be produced in this furnace.

Next I obtained a chromel-alumel thermocouple from the Tennessee Valley Authority, along with a conversion table that read in millivolts. The cheapest millivolt meter in town was $150. As a substitute, I obtained a microammeter from the Industrial Research Institute, found its resistance from a catalogue, and converted the readings to millivolts by using the formula V=IR. I now tried to grow gold whiskers from gold chloride by decomposition at a temperature of 550°C. Only a few very small (2 mm) whiskers were grown. Because of these discouraging facts and the high cost of gold chloride, I tried no more to grow gold whiskers.

The next step was to obtain hydrogen. I knew that although gold doesn't oxidize when heated, the other metals I wanted to work with do. This meant I had to design some way that would let me heat them in an oxygen-free atmosphere, or even better, in a reducing atmosphere such as hydrogen.

[*Editor:* Hydrogen is explosive. Ask your science teacher for advice before using hydrogen. Use every precaution necessary and be extremely careful.]

Because hydrogen is a highly explosive gas, great precautions had to be taken. One precaution was to flush out the furnace with a gas that would neither form an explosive mixture with hydrogen nor react with the metal while whiskers were forming. This called for an inert gas. Helium was unavailable, therefore I chose argon as a good substitute.

With these problems overcome, I was able to start experimentation. The best results were obtained with cuprous iodide, which yielded whiskers up to 50 mm. Good results were also obtained with silver chloride and ferrous bromide. Hydrogen was kept flowing through the apparatus faster than 3 meters per second (except in the case of $FeBr_2$) for no whiskers can be grown below that speed. With variations of temperature the shape, length, and width of the whiskers also varied. At high temperatures, whiskers formed in a few minutes, whereas hours were required at the lowest temperatures. See the table at the left.

Silver whiskers were grown by Michael.

TEMPERATURE TABLE

Metal	Halide	Temp. (°C)	Best Temp.	Length
Copper	CuCl CuBr CuI	430-580	650	50mm
Silver	AgCl AgI	700-900	800	10mm
Iron	$FeCl_2$	730		20mm
	$FeBr_2$	760 (low H_2 flow)		
Gold	$AuCl_3$	550		2mm

Michael Nolan's project as it was exhibited in a recent school science fair.

PROPERTIES

These metal whiskers, being crystals, have very interesting properties. Magnifications as high as 40,000 times reveal no flaws in their smooth, highly reflective surfaces. Also, the cross-sectional shapes of whiskers of the same metal show considerable variation.

One unusual fact connected with metal whiskers is that their tensile strengths approach, more than any other form of metal, the theoretical values for perfect crystals. Their small size and method of growth eliminates many of the imperfections that tend to weaken bulk metals.

Dr. E. A. Gulbransen of Westinghouse Research Laboratories found that whiskers growing from stainless steel tend to weaken it. Chromium oxide whiskers and plates found on stressed stainless steel in corrosion studies cut tiny canyons in the metal's surface, causing stress-corrosion cracking.

The latest experimentation on whiskers was recently announced by General Electric Laboratories. Cigar-shaped crystals of silicon as large as a finger have been developed. These are as free from imperfections as are metal whiskers. These crystals provide samples. They are big enough to allow metallurgists to study not only tensile strength but also mechanical, electrical, magnetic, and other properties.

You can see that experiments beginning with curiosity about metal whiskers are playing a greater role each day in metallurgy.

THIS IS THE LEVACAR, "MACH I"

. . . somewhere between Hero's steam kettle and the first spaceship

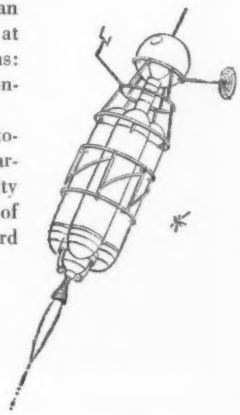
The years ahead are for the imaginative and bold. An age of liquid fuels and count-downs. Of young scientists hurtling toward outer stars in sealed missiles. Of speeds approaching that of light; distances that dwarf the sun's orbit.

Meanwhile, back on earth, over 2000 years have passed since the jet engine was first invented when Hero, an Egyptian scientist, sent jets of steam through bent tubes and made a ball spin around.

Between Hero's invention and future space flight, "earthbound" scientists at Ford Motor Company are at work on a new kind of car. It will travel over 500 miles an hour—*without wheels!*

A full-scale operating model, the Levacar "Mach I," can actually be seen today at the Ford Rotunda in Dearborn, Michigan. Three *levapads*, powerful air jets, raise it off the ground 5/1000 of an inch; another jet propels it forward at incredible speed. "Mach I" dimensions: 94″ long; 48″ high; 54″ wide. Controls are electric.

"Mach I" might well foretell tomorrow's high-speed land travel, carrying passengers swiftly over intercity distances. This is another example of the future-minded thinking at Ford Motor Company.



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Project and Club News

You, Too, Can Be a Scientist

THIS FALL more than 500,000 boys and girls will be launching their own science projects, competing in the 1960 Science Achievement Awards for Students and the Eleventh National Science Fair.

You can share in the adventure and excitement of science by doing your own science project. What is a science project? It is a study of what something is, how it came about, and how *you* can make it happen. It is a study of something that interests you.

Projects are being carried out in all branches of science, and there is room for many more. There will always be a place for you in science. There are always discoveries and improvements to be made. Perhaps the project *you* select will lead to new frontiers.

A science project will give you a good idea of the kind of work a scientist does. Your first project can be a springboard to more difficult ones.

Will you be in on the fun, excitement and *awards* to be had at the National Science Fair (NSF) and the Science Achievement Awards for Students? You can be—if you start now! But first, like a scientist, you have to get the facts. Here they are:

National Science Fair

If your local science fair is cooperating in this program (and if you are in the tenth, eleventh, or twelfth grade), you may win a trip to the National Science Fair (to be held May 10-14, 1960, at Indianapolis, Indiana) with all expenses paid by your sponsoring organization. You may win one of more than one hundred NSF awards, including a medal and a "wish" award of scientific material, apparatus or books of your choice totaling up to $125.

Ask your science teacher or Science Fair Director to get more information from Science Clubs of America, 1719 N Street, N.W., Washington 6, D. C.

Science Achievement Awards

If you are a student in a junior or senior high school in the United States, its territories, or Canada you are eligible to win as much as a $75 Savings Bond and an extra $100 Savings Bond if your project deals with metals and metallurgy. You may enter a project in any field of science or mathematics: biology, chemistry, physics, earth science, general science, arithmetic, algebra, geometry.

Ask your teacher to send for entry forms. The address is Future Scientists of America Foundation, National Science Teachers Association, 1201 16th Street, N.W., Washington 6, D. C. Entries must be mailed to regional chairmen not later than March 15, 1960.

Science Project Ideas

Where can you look for ideas? You may discover an interesting idea in one of your textbooks, in your hobby, in a *Science World* article, in a special aspect of some subject that intrigues you, in a newspaper report, or on a television program. Other rewarding sources of ideas are discussions with your science teacher and fellow students, project conferences with expert advisers, visits to laboratories, lectures, films, and demonstrations.

For more science project ideas write to Science Clubs of America for the handbook *Thousands of Science Projects* (25¢ a copy). Also write to the Future Scientists of America Foundation for *If You Want to Do a Science Project* and *Encouraging Future Scientists: Student Projects, 1958* (50¢ a copy). Still another source of projects is the *Sponsor Handbook* published by Science Clubs of America, which your teacher may obtain without cost.

Interested? Get all details and entry blanks from your science teacher. Study the rules and regulations. Start now! Allow yourself plenty of time to complete your project and to make any necessary revisions and improvements.

See you at the Future Scientists awards program or the National Science Fair—perhaps both. Good luck!

Westinghouse photo

Got an idea for a science project? Need a place to work? Would you like to meet others who share your interests? A science club is the answer. Join one today!

Starting a Science Club

Want to meet boys and girls who share your interest in science? A science club is the answer.

How do you start a science club? If there is no club in your school or community, you can start one very easily. Think of your friends and classmates.

Which ones enjoy searching for answers and thinking up new questions? Do they enjoy the thrill and excitement of discovery and exploration? Are they eager to venture into the unknown? See if they share your enthusiasm. These are the people who will make up your club.

Form a committee to invite an adult to sponsor your club. A good choice as a sponsor could be your science teacher at school, a lecturer or professor in a nearby college or university, a staff member of a local museum, a scientist who works or lives in your community, perhaps your scoutmaster.

You can help your sponsor get started by having him write to Science Clubs of America, 1719 N Street, N.W., Washington 6, D. C. Information on organizing a science club, activities for the club, free and low-cost materials to send for, science project ideas, and Science Service "Aids for Science Clubs" will be sent to him.

At no cost, your club can join the largest science organization in the world, Science Clubs of America. Sponsors of every science club affiliated with SCA, an activity of Science Service, receive the new edition of the *Sponsor Handbook*, published annually, and other helpful information, suggestions and material, without charge, throughout the year.

About 25,000 science clubs are already in action, not only in the United States but in many other countries.

An excellent meeting place for your group is the school laboratory. It usually has the most concentrated collection of scientific apparatus available. A basement, attic or other empty room will also serve your club's needs. A lack of facilities and equipment is no problem. Many minds working together on a common problem can overcome almost any obstacle in their path.

The out-of-doors can serve as your "lab" for nature study, gardening, conservation, model airplane flying, and other activities.

Starting with an interested group and a competent sponsor and very little else, your club can assemble its own laboratory and club equipment by building and borrowing apparatus. If club dues are collected, hard-to-make apparatus can be bought.

Twenty years ago, Joshua Lederberg belonged to the Stuyvesant High School Science Club in New York City. He was chosen as one of 30 promising students to work on his project at a special laboratory. Recently Dr. Lederberg was awarded the 1958 Nobel Prize in Medicine and Physiology!

Wide World photo

Joshua Lederberg (here shown with his wife) won 1958 Nobel Prize in Medicine. He got his start 20 years ago as member of the science club in his high school.

Will one of the members of *your* science club be the 1975 Nobel Prize winner?

What happens to you after High School?

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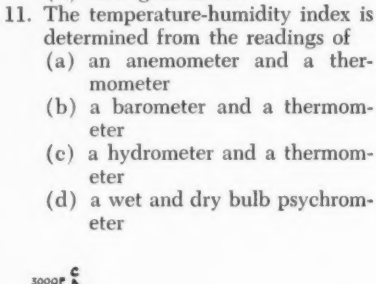
Meeting the Test

A Sci-Q Test on Recent Developments in Today's Science

How much do you know about what is going on in modern science? Are you up-to-date in your reading? Are you aware of the big problems in each of the areas of modern science? Here is a test which can tell you how well informed you are in the sciences. Of the four choices given, select the letter of the most appropriate answer. Don't expect to get 100 per cent on this test. In fact, if you get 50 per cent of the answers correct, you are doing well. Answers will be found on page 30.

On the Frontiers of Science

1. Of the following, the particle most recently discovered is the
   (a) neutrino (c) meson
   (b) positron (d) anti-lambda
2. Project Mohole will
   (a) drill a hole through the Moho.
   (b) study animals living beneath the Earth's surface.
   (c) study ways of producing controlled thermonuclear reactions.
   (d) chart the sea bottom under the North Pole.
3. Recent studies of the planet Pluto seem to show that
   (a) Pluto is larger than Neptune.
   (b) Pluto is an escaped moon of Neptune.
   (c) Pluto's orbit is in the same plane as that of the Earth.
   (d) There are definitely no planets beyond Pluto.
4. Which of the following is most closely related to the virus?
   (a) streptococci (c) spirilla
   (b) rickettsiae (d) bacteriophage
5. Of the following, the one with the shortest half-life is
   (a) uranium (c) radon
   (b) radium (d) a free neutron
6. The marked increase in deaths due to heart disease since 1934 is most closely associated with which of the following:
   (a) the increased tempo of modern living
   (b) an increase in the carbon dioxide content of the air due to automobile and industrial products of combustion
   (c) the development of the sulfa drugs and antibiotics
   (d) increased fat in the diet
7. Of the following trees, one could properly be called a "living fossil." Its appearance today shows little change in structure from its fossilized ancestors that lived millions of years ago. Which tree is the "living fossil"?
   (a) the sequoia (c) the ginko
   (b) the black oak (d) the pine
8. Recently there was a revival of interest in a discovery made by Thomas Seebeck in 1821. The area of this discovery, beginning to assume technological importance, is that of
   (a) hydrodynamics
   (b) ferromagnetism
   (c) thermoelectricity
   (d) piezoelectricity
9. Which of the following is *least* substantiated by the results of modern cancer research?
   (a) Cancer may be caused by a virus.
   (b) Cancer cells injected into the blood stream of human beings always produce cancer.
   (c) Metabolism of a cancer cell differs from that of a normal cell.
   (d) Cancer cells reproduce more rapidly than normal cells.
10. The chemical adenosine triphosphate (ATP) plays an important role in
    (a) muscle contraction
    (b) bone formation
    (c) heredity
    (d) detergent action
11. The temperature-humidity index is determined from the readings of
    (a) an anemometer and a thermometer
    (b) a barometer and a thermometer
    (c) a hydrometer and a thermometer
    (d) a wet and dry bulb psychrometer



12. Recently scientists have had to double their estimates of the size and age of the universe. They did this because:
    (a) an error had been made in estimating the real brightness of Cepheid variable stars.
    (b) using the uranium-lead ratio method, the oldest rocks on earth were found to be over three billion years old.
    (c) 200-inch telescope revealed galaxies six billion light years away.
    (d) radioactive dating methods applied to meteorites indicate that they are almost five billion years old.
13. A maser is
    (a) a nuclear particle
    (b) an extremely accurate atomic clock
    (c) a device for accurately determining weight
    (d) a type of cyclotron

Graphing a Rocket Flight

An important skill of a scientist is his ability to read and interpret a graph. Try your hand at the graph below. How much information can you get from the graph by answering the questions?

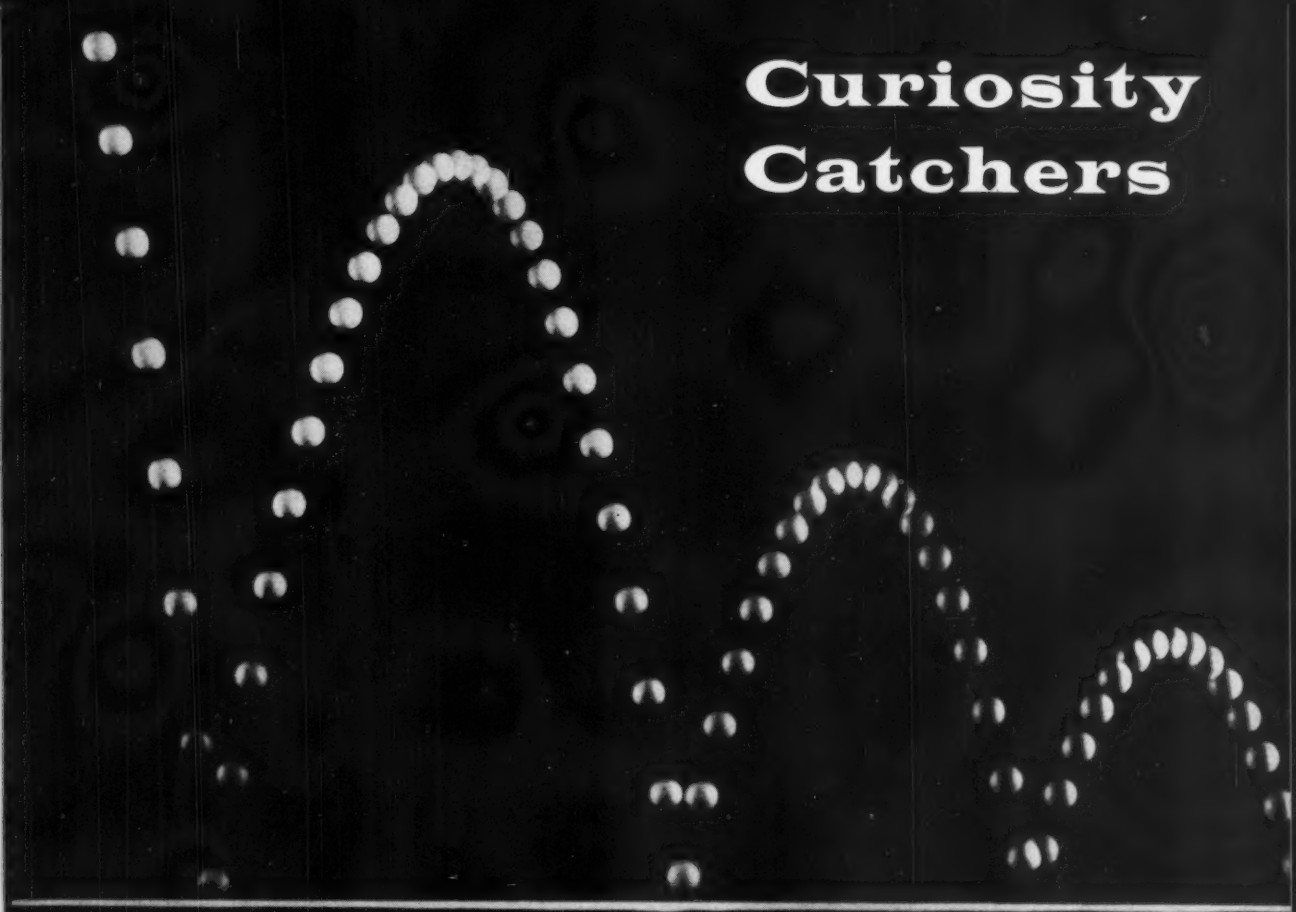
The graph represents approximately the velocity of the second stage of a small experimental two-stage rocket. The rocket was fired at t=0, and 5 seconds later the second stage fired. The second stage then rose upward to the top of its flight and returned to earth.

1. The second stage reaches the top of its flight at time
   (a) 5 sec. (c) 110 sec.
   (b) 10 sec. (d) 215 sec.
2. The acceleration of the rocket is greatest during the interval
   (a) AB (c) CD
   (b) BC (d) DE
3. The height at which the second stage fires is approximately
   (a) 500 ft. (c) 1,250 ft.
   (b) 1,000 ft. (d) 3,000 ft.
4. The height at which the second stage burns out is approximately
   (a) 2,500 ft. (c) 7,500 ft.
   (b) 3,000 ft. (d) 20,000 ft.
5. The point in the flight at which the rocket is at rest with respect to the earth is
   (a) B (c) D
   (b) C (d) E

How many graph questions were you able to answer correctly? A future issue of *Science World* will bring you an article that tells how to derive all the information you can from graphs of this type. Watch for it!

—Theodore Benjamin

Curiosity Catchers



Why does the ball lose height with each bounce?

Berenice Abbott photo for Physical Science Study Committee

Swooshing rockets, racing autos, roaring trains, crashing halfbacks, lumbering bulldozers—all of these, we know, have something pushing them along. Somewhere beneath their hustle and bustle a force is acting to keep them moving.

It takes a bit of imagination, however, to see that science, too, is a driving, moving thing. For a long time, it has been sometimes pushing and oftentimes leading men and women to explore, investigate, and discover. But what is the fuel that drives science forward? We think it is CURIOSITY, the asking of Why's and How's, of What's and Wherefore's.

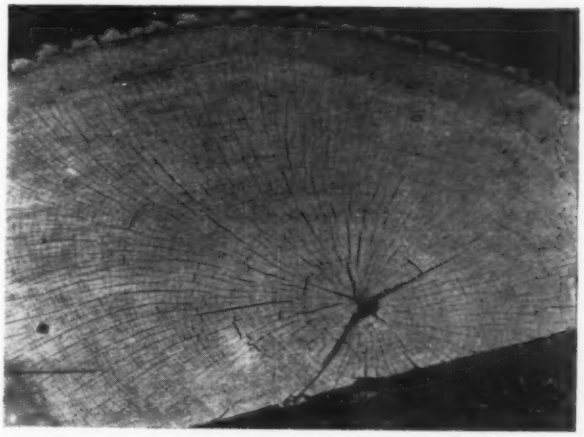
It's fun to be curious. It's like working a puzzle or guessing a riddle.

To give you some of the fun of exercising your curiosity, *Science World* will include in each issue some Curiosity Catchers, things we hope will arouse your curiosity and spark it into planning experiments and investigations.

For the science class that sends in the best plan of attack for following up each Curiosity Catcher, *Science World* will award a science reference book for the classroom shelf —a book of your choice!

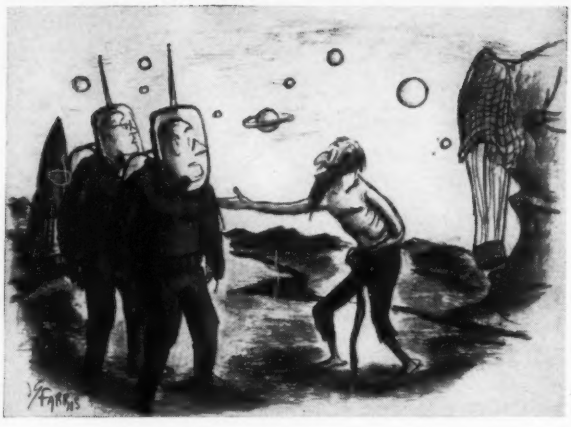
Each class entry must be postmarked not later than 30 days after the date of the issue in which the Curiosity Catcher appeared. Address your entry to Curiosity Catchers, Science World, 33 West 42nd Street, New York 36, N. Y.

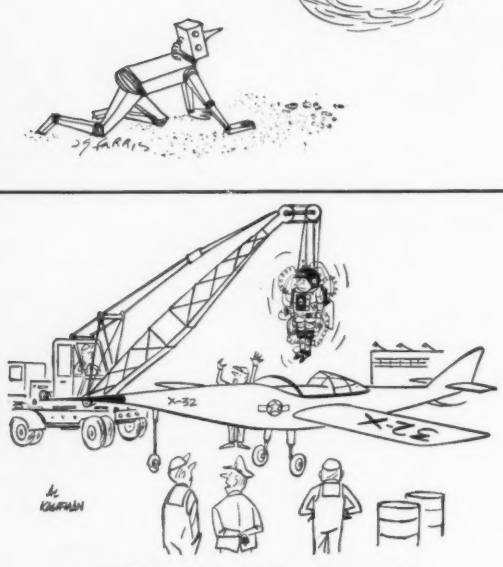
Entries will be judged on how clearly the problem is worded, on how much additional information has been brought together, on the probable fruitfulness of hypotheses, and on the strategy with which experiments or investigations are planned or carried out.



Is the checking and splitting of this stump related in any way to the cellular structure of the wood? Would the time of the year when the tree was cut down make any difference?

sci-fun





"I think we're trying to get too much information out of one test flight."

UPI photo

It travels on land but does not touch the ground. It travels on water but stays above the surface. Yet it doesn't fly. See the next issue of *Science World* for a full report on the air-car, newest development in transportation, now being tested.

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Answers to Meeting the Test

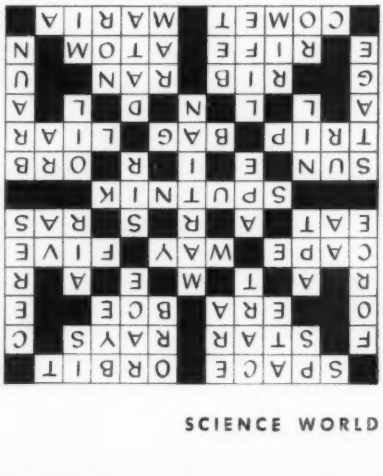
(See page 28)

On the Frontiers of Science: 1-d; 2-a; 3-b; 4-d; 5-d; 6-c; 7-c; 8-c; 9-b; 10-a; 11-d; 12-a; 13-b.

Graphing a Rocket Flight: 1-c; 2-b; 3-c; 4-c; 5-c.

Answers to Crossword Puzzle

(See page 31)

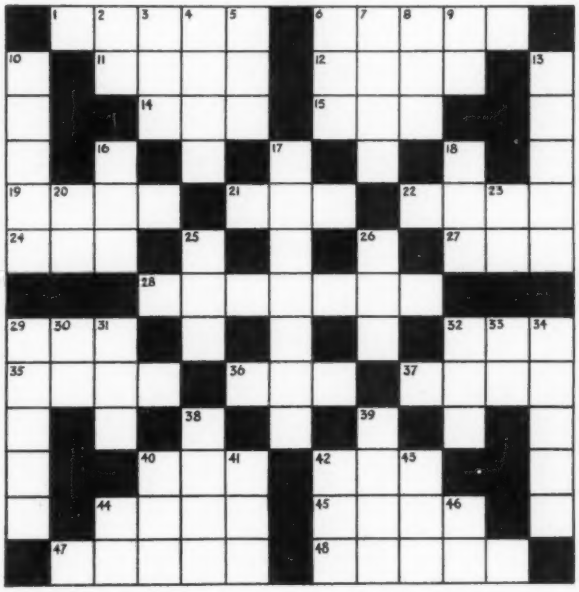


Out of This World

By Charles Johnson, Madison High School, Madison, Florida

★Starred words refer to space and interplanetary travel

Students are invited to submit original crossword puzzles for publication in *Science World*. Each puzzle should be built around one topic in science, such as astronomy, botany, geology, space, electronics, famous scientists, etc. Maximum about 50 words, of which at least 10 must be related to the theme. For each puzzle published we will pay $10. Entries must include puzzle design, definitions, answers on separate sheets, design with answers filled in, and statement by student that the puzzle is original and his own work. Keep a copy as puzzles cannot be returned. Give name, address, school, and grade. Address Puzzle Editor, Science World, 33 West 42nd Street, New York 36, N. Y. Answers to this puzzle are on page 30.



ACROSS

° 1. It begins where the Earth's atmosphere ends.
° 6. Path taken by the Earth as it circles the sun.
°11. Proxima Centauri is the nearest _____ to the sun.
°12. Cosmic _____ are solar bullets that can penetrate solid rock.
°14. October 4, 1957, was the start of the space _____.
15. Bachelor of Chemical Engineering (*abbr.*).
°19. First U. S. "moon" was launched from _____ Canaveral, Florida.
°21. The Earth is a planet in this galaxy, Milky _____.
°22. 30,000,000,000,000 miles equal _____ light years.
24. Consume food.
27. Royal Agricultural Society (*abbr.*).
°28. First Earth satellite that was launched by the Soviet Union.
°29. This blazing star is 93,000,000 miles from the Earth.
°32. A celestial sphere, such as a moon, star, or planet.
35. Journey.
36. Paper sack.
37. Person who tells fibs.
40. Curved bone inside the chest.
42. Hurried.
44. Prevalent.
°45. Scientists predict the _____ will power rockets by 1970.
°47. Heavenly body with a long train or tail.
°48. Name given to so-called lunar "seas" by early astronomers.

DOWN

2. German-American electrical engineer, Charles __roteus __teinmetz (*initials*).
3. Homonym for *eight*.
4. Small, two-wheeled wagon.
5. The _____ of good feeling.
° 6. Heavenly body.
° 7. The Soviet Union and the U. S. are contestants in a _____ into space.
8. By the _____.
9. Song in *Pajama Game*, "Her _____."
°10. Atlas and Titan are being developed by the U. S. Air _____.
°13. Largest known asteroid.
16. Suitable.
°17. Creature that may live on Mars.
°18. There is almost none of this vital substance on the moon.
°20. Achievement age (*abbr.*).
23. The Old Dominion state (*abbr.*).
25. Large, tailless monkey.
°26. He discovered Uranus in 1781, _____ William Herschel.
°29. Vanguard I was orbited by a three-_____ rocket.
30. Uranium (*chemical symbol*).
31. Nothing.
32. Petroleum.
33. Radium (*chemical symbol*).
°34. He developed the Jupiter-C rocket, Wernher von _____.
°38. Pluto is too cold to sustain _____.
°39. Collection of scientific facts.
40. Edge.
41. Wager.
42. Male sheep.
43. Either, or; neither, _____.
°44. Royal Observatory (*abbr.*).
46. Mile (*abbr.*).

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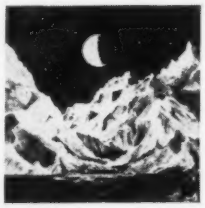

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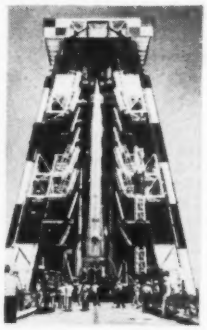

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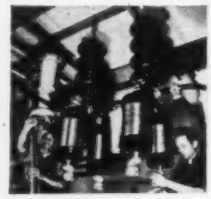

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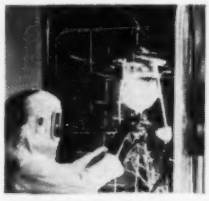

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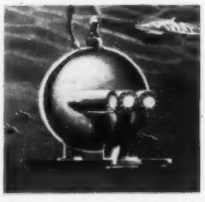

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other scientists, (4) to illustrate how the application of science depends on basic research, (5) to call attention to vocational opportunities in biology (attention should be directed not only to the biologist but to the laboratory technician as well).

During the term, when the class is studying viruses, tissue culture, or disease control, the article might be assigned to the class as a special report. In conjunction with such a report it is effective to pass around some empty anti-polio vaccine vials. The labels contain significant information. Empty vials are obtainable from physicians or from hospitals.

How Long Is a Micromicrosecond? (pp. 12-15)

Subjects: Physics, Chemistry, Biology, General Science.

Special Topics: Wave length and color, spectroscopic analysis, ultra-low-temperature phenomena.

About This Article

The author takes note of the establishment this summer of a standard inch and standard pound. "For the first time in history, the six English-speaking nations of the world—the United States, Britain, Canada, New Zealand, Australia, and South Africa—are united in what the terms inch and pound mean."

With this take-off, the author reviews the history of measurement of length and weight, from ancient times to the present. He proceeds to describe *other* units of measurement scientists have had to devise and use in their search for order in the universe. The metric system is described in great detail down to Angstrom units used in wave phenomena such as color and spectroscopic analysis in chemistry.

The measurement of *time* is traced historically from the solar day to the atomic clock, as is the history of the measurement of heat. Finally, the reader is given a peek over the horizon toward the ultimately small and the ultimately large, which may require even stranger units of measurement before they can be explored.

Teaching Suggestions

Assign this article as homework reading. Ask individual students to volunteer to prepare and give reports to the class on one of these topics:

1. Describe the origins of the *inch, hand, yard, foot.*

2. Trace the length of an "inch" from the time of King Edward II to the present.

3. Describe the early confusion concerning weight and explain how the idea of *mass* was found necessary and useful.

4. Explain why the metric system is more "efficient" than other systems of measurement in current use.

5. Describe the smallness of the *Angstrom unit,* and give examples of its usefulness.

6. Describe the history of time-measurement up to the most recent definition of a *second.*

7. Describe how temperature measurement led to new ideas about heat.

8. Describe some present-day scientific activities that may require *new* units of measurement.

There will, obviously, not be time enough in a single period for eight student reports, especially if each report is to be adequately discussed. You might, therefore, *select* from the above list of topics those most pertinent to your course of study and those most suited to the maturity level of your pupils.

This article affords teachers the rare opportunity of showing students how mathematics is the indispensable tool of the scientist. Stress the importance to the student of taking mathematics courses, without which he cannot major in any scientific field. Taking the courses in high school will enable him to be one step ahead, since all of them are prerequisite to college mathematics courses.

Discuss the field of biometrics—the science of statistics applied to biological observations. (You might point out that Mendel's two hobbies were statistics and gardening.) Do this by tying in "Our Tiniest Chemical Laboratories" article with the "measurement" article.

After the photograph of the amoeba has been studied, ask the class to find out how scientists would determine the size of such a small object. How do they measure the size of viruses and other microscopic specimens? Use the amoeba photograph to motivate the class to read the "measurement" article. Point out that biologists, as well as physicists, chemists and geologists, use mathematics.

How does the student use measurement and mathematics in his everyday life? Discuss such devices as the thermometer, ruler, and barometer to make scientific observations.

Emphasize the need for mathematicians and the opportunities now open to them. Discuss such exciting fields as rocketry, engineering, chemistry, etc., which need mathematicians.

The article on measurement might also be drawn to the attention of the mathematics teacher.

Tomorrow's Scientists (pp. 21-24)

Light Sensitivity in the Earthworm

To introduce students to laboratory activities involving some real research, spend a lesson or two on the nature of light. The classical light dispersion demonstration is performed to establish the understanding that ordinary daylight is a mixture of light of various colors (wave lengths).

The question then immediately arises: to which wave lengths do the organisms respond? To the longest ones (red)? To the shortest ones (violet)? To the middle ones (yellow or green)? To *all* of these? To *none* of these?—but to ultraviolet or infrared? By using light that filters through colored cellophane sheets, ranges of light can be produced.

Meeting the Test (p. 28)

In this issue, teachers are offered a diagnostic test. The test is intended to serve as a guide, to help you determine the extent of the modern science knowledge of your students. The results will give you a helpful index to the science interests and ability of your class.

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